NASA AUTHORIZATION FOR FISCAL YEAR 1983

HEARINGS
BEFORE THE
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE
OF THE
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE
NINETY-SEVENTH CONGRESS

SECOND SESSION

TO AUTHORIZE APPROPRIATIONS TO THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION FOR RESEARCH AND DEVELOPMENT, CONSTRUCTION OF FACILITIES, AND RESEARCH AND PROGRAM MANAGEMENT, AND FOR OTHER PURPOSES

FEBRUARY 23, 25, MARCH 16, 18, 30, AND APRIL 1, 1982

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NASA AUTHORIZATION FOR FISCAL YEAR 1983

TUESDAY, FEBRUARY 23, 1982

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met, at 9:35 a.m., in room 235, of the Russell Senate Office Building; Hon. Harrison H. Schmitt (chairman of the subcommittee) presiding.

Staff members assigned to these hearings: Carol S. Lane, Professional Staff Member, and Steven H. Flajser, Minority Professional Staff Member.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. The hearing will come to order.

I welcome our friends from NASA and Senator Cannon this morning.

This year has been a vivid reminder to the American people and the world that the United States is indeed in the space business. We have had two tremendously successful Space Shuttle flights, opening up the doors to a new era of space exploration and, more importantly, exploration. We have seen exciting pictures from the Voyager II spacecraft's rendezvous with Saturn. This has demonstrated to the world, not only our Nation's commitment to scientific endeavors, but our technology base developed for the planetary program adds credibility to our economic, technological, and defense capability. Unfortunately, that is a 10-year-old technology base. Our space program successes this year have shown the world that even during some of the most difficult of times that this country has gone through, our technological capabilities are there for continued future growth.

We must continually remind ourselves, however, that science and technology in general must be an intrinsic part of our economy recovery. Unless that reservoir is filled, it will not be possible to sustain whatever economic recovery may occur in the short or long term. We have two choices: We can coast on our past achievements with the threat of oncoming waves from both the Soviet Union and others in the free world, or we can demonstrate that our commitment to technological achievement has made our country great and will continue to do so. The milestones of our national route through history are marked almost entirely by events that have shown a very broad utilization of science and technology created by a free people, utilized by a free people to their advantage.

If we look at the major elements of our space program, we can see that the Soviet Union and the United States are no longer the only players.

In launch services, the French have declared their Ariane launch vehicle operational and are providing very attractive financial arrangements to entice customers. Needless to say—it's working. Additionally they, together with their European partners, are already providing funding to increase Ariane's capabilities, as well as looking at advanced systems to meet launch needs after 1990. They pose a continuous challenge to us in this decade and the next.

In space science, the United States will be conspicuously absent when Halley's Comet enters the inner portion of our solar system once again. Instead the comet will be met by spacecraft from the Soviet Union, Japan, and the countries comprising the European Space Agency. In fact, a French official commented on the French participation in the Soviet Union's Venus/Halley Comet mission: "It is sometimes difficult or frustrating to deal with the Soviets, and we had to make changes on some projects, but the end result is space experience we otherwise would not be able to achieve."

In addition, it appears that the Western Europeans are finalizing plans for a follow-on Spacelab program that may lead to a free-flying orbital laboratory in the 1990's. The Europeans are no longer constrained by a dependency on the United States.

In space applications, the French SPOT system may provide the world with satellite images of the Earth while we continue to flounder in development of an operational capability for Landsat.

The Japanese are aggressively pursuing satellite communications technology and have established as one of their 15-year goals to advance communications technology and develop their own technology base. The 30/20 gigahertz program is perhaps the most visible example of the Japanese challenge. The French are offering support in consortia that the United States does not. In fact, in the few years or so, I would expect to see the United States excluded from the satellite business of the world unless we do something dramatic, and soon.

In aeronautics, our challengers are numerous. U.S. manufacturers of commercial transports have lost more than 20 percent of their market to European competitors over the past several years. It is safe to say that we do not have a computer aircraft industry of any significant proportions. Additionally, the U.S. market share for rotorcraft has decreased by 15 percent at a time when the world market is expanding. The European community has set policies and plans to displace U.S. leadership in aviation by the end of the decade. Following this lead, the Japanese, Canadians, and the Brazilians have incorporated civil aircraft development and production in their national industrial plans.

In examining these few examples, and unfortunately there are many more, it is necessary to highlight that these other nations are pursuing space and aeronautical technology because of its commercial and scientific value. We must recognize now, perhaps more than ever, that we cannot afford to use national defense as the only justification for our own civilian space program. For if we do, we may very well watch our efforts for a strong national defense wither away along with our economic strength, and the foundation of technology upon which that depends. There is a misguided perception that the flow of technology in our commercial sector is always from defense outward. There is now, and always has been, a significant flow of technology related to our national defense, that had its origins in the civilian sector.

We cannot merely look back at past accomplishments, no matter how great, and say we have made a commitment to space. We need to adjust to changing situations. Just as our current situation is one of Federal fiscal austerity, it is also one of competition from other nations anxious to exploit the technical and economic opportunities of space. If we are going to compete, if our industry is going to compete, we need a strong civilian space program.

Today begins the first day of NASA fiscal year 1983 budget authorization hearings. In reviewing the budget this year, we will focus on the programs of the space transportation system toward an operational status and the balance between space science, space applications, aeronautics, and space technology in meeting our future activities.

We will also look very, very carefully at the balance between investments in the civilian sector that relate to our national defense and investments in the defense sector that relate to our civilian capability.

Senator Cannon?

OPENING STATEMENT BY SENATOR CANNON

Senator CANNON. Thank you, Mr. Chairman.

The Soviets launched 25 years ago, a small satellite called Sputnik that was to transform the world. The United States responded to this perceived security threat and clear challenge to our leadership. We became preeminent in space and we received the benefits of this effort.

On this silver anniversary, I would like to raise this question: Will we continue to be the world's leader in space? Unlike 1957 when the U.S.S.R was our only competitor, today we also face competition from the French, the Germans, the Japanese, and others, particularly for commercial purposes.

What is at stake today is more than prestige and technological leadership, although this should not be overlooked, but rather an ability to capture the benefits that utilization of the space environment provides and in particular the economic benefits. Since I gave a speech on the importance of preeminence in space to the Senate last fall, I will not dwell on this point further. I do ask that we include that statement in the hearing record.

Today we open hearings on NASA's fiscal year 1983 budget request. I for one will be looking at this request in light of our need to maintain this preeminence and thereby maintain our economic opportunities. I have not spent 23 years serving on the authorizing committees for NASA and worked with both Democratic and Republican administrations only to see the shortsighted budget preoccupation of today foreclose the numerous economic and other benefits we would receive from our investments in NASA.

I am not suggesting it is the NASA management that needs to correct their vision; the myopia likely rests elsewhere. While I am encouraged with the modest increase the budget provides, I doubt this budget provides sufficient effort in planetary exploration, space applications, and aeronautics. For example, NASA is curtailing activities vitally important to our economy in communications R. & D. and aeronautical systems technology. With regard to this latter area, we still have outstanding the issue of the fiscal year 1982 operating plan.

Mr. Chairman, not all of my questions involve budgetary matters. I share your concern that this administration has yet to realize the importance of space. We have not made any visible progress in setting forth a new space policy or establishing new goals for the Shuttle era. Policy regarding operational land remote-sensing systems still needs to be resolved. And what are we doing to encourage additional private sector involvement in space, for example, in areas such as space transportation and materials processing? If this administration does not come forward with proposals, I sense that Congress once again will. And I would like to work with you and others in this effort.

Thank you.

[The speech referred to follows:]

[From the Congressional Record, Nov. 23, 1981]

THE IMPORTANCE OF AMERICA'S PREEMINENCE IN SPACE

Mr. CANNON. Mr. President, once again the Space Shuttle has flown successfully and returned to Earth, and I would like to take this opportunity to congratulate the fine NASA-industry team which made this flight such a success and the magnificent skill of Astronauts Joe Engle and Richard Turly.

Unlike other nations, the United States is not afraid to let the international press view every step in the development of its civilian space program, and the Space Shuttle has not been an exception. We are willing to share with the world our successes as well as our failures as we develop this tremendous capability.

The fact that NASA has a problem with one of the three fuel cells on board the Shuttle should not cause undue concern. The Shuttle needed only one operable fuel cell to be able to return to Earth, and any research and development effort, such as the Space Shuttle, requires a period of time to work out the "bugs" in its design.

It takes a lot of talent, effort, and dedication to translate the initial conception of a major space system like the Shuttle into an operational reality, and I am fully confident that we will develop this capability. We are, with this first-time-ever return of the same vehicle to space, well on the way to doing so.

Mr. President, while I am proud of the continuing success of the Shuttle's development, I am also concerned about a waning resolve to move forward and insure our preeminence in space during the 1980's. The Space Shuttle, as magnificent as it is, is still just a transportation system capable of transferring astronauts and cargo from the Earth's surface to an orbit several hundred miles above the Earth.

What we ought to be thinking about and planning for now is how to use this capability for various commercial, scientific, and national security missions, and defining what other basic capabilities are needed to complement and enhance our use of the Shuttle.

While we follow the development of the Shuttle into an operational capability, we must recognize that we cannot stand still in the other areas of the space program. We must also invest in these areas as well, or we will lose our leadership in space to other nations who are willing to make the investment—and other nations are moving in that direction.

Our investment will not involve large amounts of additional funding, but rather a commitment to fund NASA in the future at approximately its current level, adjusted for inflation.

In the past our main source of competition was the Soviet Union. This no longer is true as other nations develop the capability to operate in space. We are entering a new era of international competition in space, particularly for commercial purposes. The primary competitors in the future, in addition to the Russians, will be the Europeans and the Japanese.

We must view our space program in this new context of competition while retaining the long-standing benefits of cooperation in the exploration of the solar system and the universe beyond.

Let us also not lose sight of the goal, stated in the National Aeronautics and Space Act of 1958, that:

Our activities in space should be devoted to peaceful purposes for the benefit of all mankind.

The use of space for national security purposes has helped to preserve world peace and lessen the likelihood of a global war. Since some of the capabilities needed by the military space program are also needed by the civilian space program, a development in one area can be used in the other.

The Space Shuttle is one example of this, and weather satellites are another. Thus, funding for our civilian space program can either directly or indirectly aid our military space program.

The commercial use of space, while almost 20 years old, is still in its infancy. During the 1980s, a tremendous growth in the use of communications satellites is anticipated. Not only will existing services be expanded, but new uses will also be developed.

In addition, the use of satellites to detect and monitor the Earth's resources, and the manufacture of various products in space are being investigated by NASA and industry, and these capabilities may further expand our commercial use of space in the 1990's.

In a real sense, our commercial use of space parallels our commercial use of aviation. Today, aviation is at least a $100 billion a year enterprise in the United States alone. Who would have thought that this would have occurred at the time of the Wright Brothers' first flight, or for that matter, at the time of Charles Lindbergh's *BAD MAG TAPE**ERR01*flight about 20 years later.

Our continued commercial success in the field of aviation depends upon NASA doing the high risk research and development that industry cannot afford to do. Without that help, our industry would soon lose its preeminence to foreign competition.

Similarly, our preeminence in the commercial use of space depends upon NASA performing the high risk research and development in order to develop the knowledge necessary for private industry to build viable commercial systems.

The exploration of the solar system and the universe beyond is the greatest adventure of our time, and the Apollo, Viking, and Voyager missions may someday be seen to have been as important to the world as the voyages of Columbus, Magellan, and Drake. Not only are we learning a vremendous amount about the origin ane nature of the universe, but we are also laying the foundation for the expanded use of space by future generations of Americans.

EXPANDING OUR COMMERCIAL USE OF SPACE

Mr. President, I should now like to describe the three areas that are likely to lead our expanded use of space for commercial purposes in the next 10 to 20 years: Communications satellites, remote sensing satellites, and the manufacture of various products in space.

COMMUNICATIONS SATELLITES

Communications satellites have been the only commercial product that has made a profit in the past. This business will continue to expand during the 1980's. According to a recent comprehensive study by Western Union, the worldwide communications satellite market is estimated to be $35 to $50 billion over the next 20 years.

The U.S. market alone is estimated to be $16 to $20 billion during this time period.

This estimate includes such potential new services as video teleconferencing which could improve productivity and reduce the amount of business travel; and the direct broadcast of television signals from a communications satellite to individual homes which could vastly increase the number of television channels received and would not require the installation of an extensive cable television network.

Starting with the Syncom series of spacecraft which established the feasibility of using the geosynchronous orbit, the United States has led this field for many years. NASA developed a significant in-house expertise, funded the development of new technology by several U.S. contractors, and played a leadership role in making this a uniquely U.S.-dominated field.

In late 1972, the U.S. Government thought that the industry had matured to the point where it could support its own R. & D. needs and decided that NASA should not initiate any communications satellite flight programs beyond the sixth applications technology satellite (ATS-6).

The funding for such programs, which had ranged between $80 and $120 million per year, in 1981 dollars, over the period 1962–74, was sharply reduced to approximately $10 million per year.

The reduced amount was just sufficient to allow operation of on-going experiments, low-level technology development, and limited system concept studies.

Europe and Japan were quick to fill the vacuum left by NASA's withdrawal from satellite communications, as evidenced by their increased investment and rapid rise to leadership in several communications satellite technologies.

Even more important is the fact that European and Japanese manufacturers are moving from the fabrication of components to the fabrication of subsystems and complete systems, and changing their roles from that of subcontractor to prime contractor.

A recent Japanese report estimates that Japan's space industry will expand to five times its present size by 1990 and continue this growth during the 1990's. Much of this growth will occur in communications satellites. Let us make sure that we do not wind up buying our communications satellites from Japan in the future and becoming second-best in another commercial sector.

In order to meet this challenge, NASA working with the communications satellite industry, should develop the 30/20 GHz frequency band. This will enable the United States to maintain its preminence in communications satellites into the 1990's.

REMOTE SENSING

Remote sensing satellites can help us discover new sources of non-renewable resources, monitor the size and quality of our water supply and agricultural crops, and detect major sources of environmental pollution.

Thus, they can help us sustain and improve the quality of life around the globe by providing us with accurate information with which to make vital decisions which will affect us all.

For more than a decade, Congress has expressed an interest in establishing an operational civil land remote sensing system. The operational system would build upon NASA's experimental Landsat system.

The evolution to an operational system has not yet occurred because the financial risks in operating such a system are great and the profit not clearly defined. The Carter administration proposed that the Federal Government operate an interim operational system during the 1980's until it was feasible for private industry to take over the system.

Earlier this year, the Reagan administration decided that the Federal Government should limit its support for an interim system to Landsats D and D', with the hope that private industry would take over the system after the demise of Landsat D'—nominally about 1988.

The goal of having the private sector take over the system was the same; the difference between the positions of the two administrations was in the timing and the role of industry and Government.

Recently, the Senate Subcommittee on Science, Technology, and Space and the House Subcommittee on Space Science and Applications held joint hearings to gather additional information and opinions on the best way to accomplish the transition to an operational system and the role of private industry in such a system. There was general agreement among the witnesses that:

First, the Landsat data was useful;

Second, data continuity and increased marketing was the key to the success of an operational system;

Third, the cost of the data should be more realistically priced; and

Fourth, NASA should continue to do the high risk R. & D. in remote sensing.

There was no agreement on the best way to accomplish the transition to an operational system and the role of private industry in it.

Additional time will be needed before this can be resolved. One thing ought to be clear, however, the United States has invested over a billion dollars in developing a civilian remote sensing capability, and we should think of a payoff in this area on a long-term basis.

Now is not the time to be penny-wise and pound foolish and thus lose our commercial remote sensing capability to foreign competition.

The French are planning to build a remote sensing system called SPOT. Their first satellite will be launched in 1984, and it will have some performance characteristics that are better than, or not available with, the Landsat satellites.

Japan, the European Space Agency (ESA), and India are also studying possible additional remote sensing systems during the 1980's. Competition with our Landsat system is real and just over the horizon.

With this in mind, I would like to propose an approach for the transition to an operational remote sensing system which will enable it to occur as soon as possible, protect the public interest and the U.S. taxpayers' investment, and permit the maximum participation by private industry. The U.S. Government should insure data continuity by agreeing to continue to operate the space segment, that is, the Landsat satellites, until the early 1990's or until industry is capable of taking over the space-based segment, whichever comes first.

Private industry would take over the operation of the ground segment on a competitive basis. Raw data transmitted to the ground from the Landsat satellites, as well as processed data, would be sold to anyone who wishes it.

This will encourage maximum competition in private industry and enable private industry to market the data to as many users as possible.

By pursuing the above approach, we will provide sufficient time to permit additional information to be obtained on the usefulness and cost of providing remote sensing data. We will also guarantee the continuity of data for a sufficient time in the future to match any known foreign competition and to satisfy the needs of the user community.

MANUFACTURING IN SPACE

The United States, Russia, Germany, and Japan have conducted, or are planning to conduct, scientific experiments in space with various materials. This area of the space program is at a very early stage of development, and no one appears to be able to state exactly what the costs and benefits are of manufacturing various products in space.

Pharmaceuticals and semiconductor crystals appear to be the likeliest commercially viable products.

In addition to manufacturing products in space, the results of the initial experiments on materials in the absence of gravity may also improve the manufacture of Earth-based products by providing a better understanding of the effect of gravity upon various materials as they are processed.

CONTINUING OUR EXPLORATION OF THE SOLAR SYSTEM

Mr. President, the exploration of the solar system increases our scientific knowledge, adds to our understanding of the Earth, raises the level of our technology, is a source of national pride and international prestige, and fits our pioneering heritage.

Futhermore, it is carried out in fulfillment of the first stated objective of the National Aeronautics and Space Act of 1958; namely, "The expansion of human knowledge of phenomena in the atmosphere and space." From the viewpoint of NASA's budget, it is not a large amount of money. Clearly, this effort should be continued.

Recently the two Voyager spacecraft passed by Jupiter and Saturn and gave us the first detailed look at both of these planets. Voyager II is now on its way to an encounter with Uranus in 1986 and Neptune in 1989.

Thus, by the end of this decade, all of the major planets and their moons will have been visited by unmanned spacecraft, with the exception of Pluto. However, we have just begun to understand the solar system. Not only should we be planning additional planetary missions, but we should also be planning missions to some of the comets and asteroids as well.

In a congratulatory message sent to the Voyager team earlier this year, President Reagan stated:

> No other area of endeavor so galvanizes and inspires the American spirit as the conquest of space.

Unfortunately, these fine words have not been matched with needed funding in this area. Quite the contrary, the United States recently withdrew from the joint International Solar Polar Mission in which the Europeans have invested so heavily. This can hardly help our credibility on future international programs.

The United States has also missed the opportunity to send a probe to Halley's Comet during its closest approach to the Sun. Its next approach will be about 80 years from now. What is even more disturbing, the continued exploration of Jupiter and Venus, with the Galileo and Venus orbiting imaging radar (VOIR) projects is in some doubt.

I believe that we can and must do better than this, that funding for our unmanned exploration of the solar system should be continued, and that the United

States should be planning a major mission for 1992—the 500th anniversary of Christopher Columbus' landing in the New World.

DEVELOPING OUR BASIC CAPABILITIES TO OPERATE IN SPACE

Mr. President, we ought to take the long view about our use of space beyond the 1980's and proceed accordingly. The Space Shuttle is a step in the right direction. It is a reusable spacecraft which can transfer astronauts and payloads from the Earth to orbits several hundred miles above the Earth in an economically more attractive manner than using expendable launch vehicles.

In addition to developing the Space Shuttle, NASA is also beginning to define the capabilities needed for an orbital transfer vehicle and a space station. These and other related capabilities will provide our Nation with the basic tools to expand our presence in space for commercial and national security purposes, and some of these capabilities could also be used to expand our exploration of the solar system.

Since about 40 percent of our satellites are placed in geosynchronous orbit 22,300 miles above the Earth's surface, another reusable vehicle, called an orbital transfer vehicle, will eventually be needed to transfer astronauts and payloads from the Space Shuttle to geosynchronous orbit. And, to allow the Space Shuttle to perform its primary task of transportation, a space station will be needed in orbit several hundred miles above the Earth. The space station will take over the Shuttle's in-orbit functions. This will include: Deploying, servicing, and retrieving satellites; berthing, maintaining, and refueling the orbital transfer vehicles; and performing various experiments in space.

FUTURE CHALLENGES

Mr. President, my comments should not be interpreted to suggest that the benefits to be gained by expanding our use of outer space will come automatically or easily. There will be challenges of a technological nature and policy issues that we will need to address.

For example, the Space Shuttle is still an experimental vehicle. Much still remains to be done before it can be viewed as operational. When it becomes operational, we will face other questions such as: Who should operate it, what should the pricing policy be for commercial launches, how many Shuttle orbiters will we need, how long will we have to have expendable launch vehicles, and so forth.

In the area of space science, how do we pick up the pieces and resume our policy of international cooperation after canceling the U.S. spacecraft for the joint United States-European International Solar Power Mission?

In the area of space applications, what is the best way for us to help less developed countries use space for various commercial purposes, and should we go to the U.N.-sponsored conference UNISPACE 1982?

Another area of concern is assuring that NASA has an adequate work force to perform the tasks that ought to be done to maintain our preeminence in space. It is essential that NASA have positions available to reinvigorate the work force in a rapidly changing technical environment, and to halt the increasing average age of agency personnel.

Without a steady influx of new people, NASA will be without the capacity to accomplish the research, development, and management tasks essential to maintaining leadership in space technology.

One final point on the personnel issue. A prerequisite to attracting and retaining new and outstanding talent is a recognized national commitment to a comprehensive space program such as the one I have outlined above.

All of the tasks that I have mentioned could be accomplished during the next 10 to 15 years without requiring a large increase in future funding for NASA. In fact, NASA's budget would continue to remain less than 1 percent of the overall Federal budget.

What is required, is a halt to the further decline in NASA's budget, and to provide NASA with an annual level of funding in the future which is approximately constant and equal to its current budget, adjusted for inflation.

We ought to recognize that our civilian space program is not just another line item in the Federal budget. Not all Federal expenditures are the same. Some, like the space program, are investments that will provide many long-term benefits, and because of this distinction, it is vital that we halt the decline in support for the space program which has occurred over the past 15 years.

Mr. President, President Kennedy recognized the importance of our civilian space program and made the decision to send men to the Moon by the end of 1969. In 1962, Kennedy stated:

"Our leadership in science and in industry, our hopes for peace and security, our obligations to ourselves as well as others, all require us to make this effort, to solve these mysteries, to solve them for the good of all men, and to become the world's leading space-faring nation."

At the present time, we are the world's leading space-faring nation, and it is my hope that we will remain so in the decades ahead.

Senator SCHMITT. Thank you, Senator. Your comments are well taken. It is quite frustrating, and I know you feel it as well, that no matter what administration is in power, we seem to have the same testimony. And I hope that maybe one of these days, hopefully this year, there will finally be an awakening as to the role that civilian research development plays in the economy, as well as in the furtherance of our national defense.

Mr. Beggs, it is great to have you with us. It was a very confused time last year, as you were coming on board. We now hope that the confusion, at least in your mind, has left, and that we can review the NASA programs with you this morning and look forward to the future.

STATEMENT OF JAMES M. BEGGS, ADMINISTRATOR, NASA

Mr. BEGGS. It is a pleasure to appear here today to present President Reagan's budget request for NASA for fiscal year 1983. The total request is $6.613 billion, of which $5.334 billion is for research and development, $100 million is for construction of facilities, and $1.179 billion is for research and program management. A chart summarizing the request is appended to this statement.

During his first year in office, the President has clearly stated the two major policy priorities of the administration. The first is to revive our economy and the second is to strengthen our national security. The control of inflation has been identified as this administration's primary economic objective. Since inflation is related to spending by the Government, the total request, as submitted, reflects significant steps to reduce spending in fiscal year 1983. At the same time, the military and political threat posed by the Soviet Union has increased steadily during the past two decades. Improving the Nation's defense posture is clearly the second major priority of the administration. The fiscal year 1983 budget request for the National Aeronautics and Space Administration has been prepared to be consistent with these broad and overriding priorities.

Senator SCHMITT. If I could interrupt, I would say that I agree with that paragraph you just completed, but I also wish you had included—and might include for the record at that point—a paragraph outlining the importance of investments such as those of NASA which serve to increase our national productivity, which is also a way of fighting inflation.

Mr. BEGGS. All right, sir, I would be pleased to do that.

[The following information was subsequently received for the record:]

The most significant economic effects of NASA spending are the long-run productivity advances from new technologies developed for the space and aeronautics programs. Many NASA sponsored advances in air and space transportation, communications satellites, remote sensing satellites, and other innovations have improved the productive capacity of industry and stimulated the development and growth of many new businesses. These expanded business opportunities have and are expected to continue to stimulate more productive, non-inflationary private sector economic growth and job creation.

Althouth it is difficult to assess the results of the various macroeconomic studies of the effects of NASA spending on GNP, it is apparent from analyses done by the Midwest Research Institute, Mathematica, Inc., and others, that NASA high technology R&D expenditures have returned more to the economy in substantial and long-lasting productivity gains than has been spent. Since these gains are through spinoff commercial advances, they are "extra" returns above and beyond the primary goal of NASA programs: the successful completion of the various R&D mission assignments to meet public sector needs. Therefore, any gains which show positive economic returns in the long-run indicate a non-inflationary, significant return to the citizens of the United States.

Senator SCHMITT. Please continue.

Mr. BEGGS. Before turning to the details of the request, I would like to review the significant contributions and challenges which I foresee for the agency in the coming fiscal year.

The United States has conducted a vigorous space program for almost a quarter century under the broad policy guidelines set by the Congress in the National Aeronautics and Space Act of 1958. This farsighted piece of legislation has made it possible to conduct a program in both the public and private sectors that has led to truly remarkable scientific and technical achievements and to ever-increasing investments in terms of real dollars in aviation and space operations. The large commercial communications satellites now in geostationary orbit are the direct technical descendants of NASA's early applications technology satellites. The relative stability of the world today is dependent to a considerable extent on national security related satellites employing technology that was pioneered by NASA in the 1950's and 1960's. The success of this technology transfer to the commercial and military sectors is demonstrated by the fact that NASA today accounts for a smaller fraction of the national spending on space-related activities than in the past even though the NASA budget has remained relatively constant in real year dollars for the past few years. The national-security-related space program and the commercial programs have both seen very substantial increases in the past 5 years. These increases are related to important national security requirements as well as new commercial opportunities. The ability to satisfy these requirements and to exploit these opportunities is due, in large measure, to the work performed by NASA over the years.

In accord with the administration's policies, NASA's fiscal year 1983 program shows the retention of, or increases in, those programs that can be related directly to national security. We have also maintained a strong program in those fields directly related to the responsibilities of NASA under the National Aeronautics and Space Act. However, some programs have been reduced or delayed because of the urgent need to reduce Federal spending. We have heard expressions of concern that this balance of priorities can lead to the militarization of the agency. I would like to assure you, Mr. Chairman, that this administration is strongly committed to the maintenance of an independent NASA charged with pioneering new enterprises and technologies that will enhance the ability of the United States to conduct operations in space and aeronautics that further the objectives laid out in the National Aeronautics and Space Act and maintain the competitive posture of this country in aeronautics and space technology.

The past year was a historic one for the development of new capabilities in space. The first flight of *Columbia* in April was a milestone that marks a fundamental change in the way space operations will be conducted in the future. The second flight in November was the first time that a spacecraft has been reused in its entirety—flown again, and recovered. The original concept of a reusable spacecraft that was developed by NASA in the late 1960's has, therefore, been proved and the Nation can be justifiably proud of this achievement.

We have fully funded the important elements of the Shuttle program in our fiscal year 1983 request. The highest priority we have set for NASA is to complete the development of the Shuttle and to turn it into an operational system. Safety costs are primary objectives as we move forward with the Shuttle program. We are continuing to take the necessary technical and management steps to make certain that safety will not be compromised and that reliability will exceed that of our current generation of launch vehicles. Cost control is equally important to the viability of the system. This aspect is sharpened by the serious competition for launch services that we now face from the Europeans.

The steps which we shall take to control the cost of Shuttle operations will fall into two broad categories:

First, we will reduce the number of people necessary to conduct Shuttle operations. We believe that this can be accomplished through a number of incremental steps, as we gain flight experience, without compromising safety and reliability. We plan to make a careful analysis of the actions which we must carry out to plan and conduct Shuttle operations. This analysis will include requirements and procedures for flight planning, payload integration, vehicle servicing, test, and checkout. We will then be in a position to streamline our civil service and contractor structures to match those requirements.

Second, we must reduce the cost of producing the consumable items used for each flight and of refurbishing the items that are reused from flight to flight. The external fuel tanks are essentially handmade, and they are perhaps the best example of what we have in mind. We believe that substantial production cost reductions are possible as we make necessary investments to automate production procedures. In other areas, I expect flight experience to lead to design changes which will permit operational cost savings.

We have made some significant program reductions in various areas in order to help meet the administration's objective of fighting inflation by reducing Federal spending. These reductions have been made in those portions of our aeronautics and space applications programs where we believe it is appropriate for the private sector of our economy to play a larger role. It is important to recognize that we have not reduced spending on basic research and technology that could support new initiatives in civil aviation or in space applications. What we have done is to reduce our work in which performance by the private sector appears appropriate.

We have also reduced some of our activities in space science and space exploration. In making these reductions, we have placed the highest priority on work in astronomy and space physics because we believe that discoveries of an unusually important and fundamental nature will soon be forthcoming in these important areas. We have, therefore, funded both the Space Telescope and the Gamma Ray Observatory. There is good reason to believe that the Space Telescope, to be launched in 1985, will be the most important scientific instrument ever flown.

We have retained the Gamma Ray Observatory for launch in 1988 for the same reason—because gamma rays are probably the most sensitive indicators of what happens in objects where very energetic processes are occurring. We have made some reductions in our planetary exploration program, most significantly deletion of the Venus Orbiting Imaging Radar [VOIR] mission, but we have retained funds for the Galileo mission in the fiscal year 1983 request. I might add that on the VOIR we are examining other ways to do that mission which are perhaps a little less expensive. The planetary program realized enormous success in the last decade. We believe, however, the time has come to reevaluate this program and to set new direction for the future. Several scientific study groups within and outside NASA are now studying the future of the planetary exploration program. We believe that the outcome of these studies could lead to the development of some less expensive missions for the late 1980's and early 1990's as well as more ambitious concepts such as manned visits to Earth-crossing asteroids and perhaps the nearby planets in the years to follow.

As noted earlier, the policies the administration is developing to shape the future of the American space and aeronautics program are consistent with the National Aeronautics and Space Act. They provide for the retention of two administratively separate activities in space—one related to the national security and another related to essentially civilian activities. While this separation is maintained, we are working actively to strengthen relationships at all levels between NASA and those elements in the National Defense Establishment for activities in space related to the national security. You will see evidence of this when you examine the details of our program. We strongly support this administrative separation and believe that the arrangement has served the national interest well in the past and will continue to do so in the future.

A fundamental requirement of the Space Act is to preserve the role of the United States as a leader of space technology. For the last decade, the major policy objective of the space program has been to provide routine access to space. To implement this policy objective, we have created the Space Shuttle. Although we still have much work to do to turn the Shuttle into an operational system, we believe that the time has come to set new policy objectives and to plan the technological initiatives required to implement them. For example, an operational Space Shuttle leads to the possibility of establishing a permanent presence in space, as a major national initiative in space, and we have begun appropriate discussions within the administration to this end.

Several other policy and institutional issues are currently under review by study groups organized under the auspices of the Office of Science and Technology Policy. These include studies dealing with institutional arrangements in aeronautics and in Space Shuttle operations and with technical questions concerning the stable of launch vehicles that the Nation's space operations will require in the future. We expect that these studies will be completed in the late spring or summer of this year. NASA is well represented and deeply involved in these studies.

Finally, I would like to say a word about the NASA organization. In the past 6 months, we have made some organizational changes that will hopefully make it easier for me to spend more time on the major policy questions that I have just outlined. We have improved communications and streamlined overall management control by reducing the number of people who report directly to me. We have consolidated the Offices of Space Science and Space Applications into one organization to strengthen the common technical and management elements inherent in the previously separate organizations. We have broadened the authority and responsibilities of the program associate administrators by having the field centers report directly to them rather than to me. I believe that the organizational steps we have taken will make it possible to delegate authority more readily and improve the overall operation of the organization. In the coming months, we will be taking other organizational steps with these objectives in mind.

With your permission, I would like to submit the balance of my statement for the record.

Senator SCHMITT. That will be done, and it will be laid into the record.

Do you have the figure for the total number of people who report to you?

Mr. BEGGS. Not at my fingertips, Mr. Chairman. When I came to the agency, I think there were almost 35 or 40 people. We cut that almost in half. I will get the exact number.

[The following information was subsequently received for the record:]

A total of 17 professionals report to the Administrator and Deputy Administrator. In addition, there are four individuals on special assignment who report to the Office of the Administrator.

Senator SCHMITT. When you get down to five or six, you are probably in a manageable situation.

The Romans, found that they could manage 10 in a military context.

Mr. BEGGS. The tighter the span, the better the management and control. As you know, over the years, we have added a number of people who must report directly to the Administrator by statute which adds to the number that you have by reason of the basic structure of the organization. But, I think we have an effective span now. I get to see most of them every week or every other week.

Senator SCHMITT. We will begin with our 5-minute rule and alternate back and forth as other members arrive.

Mr. Beggs, the NASA fiscal year 1982 operating plan contains a significant decrease in aeronautics research and technology from the March 1981 budget and the level authorized by the Congress and appropriated by the Congress.

Additionally, there were several major items included that were not submitted to the Congress.

How do you justify this significant departure from congressional intent relative to the 1982 operating budget?

Mr. BEGGS. What we did was to interpret the authority that the Congress gave us within the appropriation accounts as a consequence of the 4-percent reduction that was made across the board to our appropriation when we settled on the fiscal year 1983 total. We developed the fiscal year 1982 operating plan in accordance with the decisions that were made in that fiscal year 1983 program.

If you will look at the aeronautics account, you will notice that the amounts included in the programs that were funded in the fiscal year 1982 operating plan are similar, if not essentially the same, as those which we intended to carry on in fiscal year 1983. This was an administrative decision which we felt was prudent in light of the management conclusions that we had reached in our discussions of fiscal year 1983 budget.

Senator SCHMITT. Let me try and interpret that. You say you think you followed the intent of Congress?

Mr. BEGGS. Yes, sir, I do. But, I think, we thought we were being prudent in a management sense in that we were adjusting the accounts in fiscal year 1982 so as to be consistent with the proposals we were making to you for fiscal year 1983.

Senator SCHMITT. That is not very prudent in a congressional sense, because the Congress obviously was giving a different direction—and the measure is signed into law for 1982—than the administration has proposed in that budget. And to assume, then, that we are going to approve a different set of priorities in 1983 did not seem to be very prudent to me.

Mr. BEGGS. What we did was interpret the authority you gave. We interpreted the 5-percent across-the-board cut which was enacted late in the session to be applied to the appropriation account. We adjusted within that appropriation account, and with the decisions we had made for fiscal year 1983. So, our position is that we did follow the general intent of the Congress, but with particular attention to aeronautics which we funded at levels which we expected to continue into fiscal year 1983.

As I mentioned earlier, there were a couple of other things which were uppermost in our mind. One is that we did give priority to the Shuttle test production and operations activities because we did consider that to be the top priority in maintaining the leadership of the United States in space. We also did our best to maintain a balance between the various other programs within the agency, with particular emphasis on space science and the ongoing programs in that area.

Senator SCHMITT. We are coming to a different set of interpretations, Jim, on what you did.

Mr. BEGGS. I understand that.

Senator SCHMITT. And we realize the constraints under which you are operating within the administration, but it does seem both in March and in this new operating plan, that the administration has protected the Shuttle at the expense of other priorities of the Congress, not that the Shuttle should not be protected. Overall, it would seem that NASA is bearing the burden for the development of the Shuttle totally and for the development of defense-related aeronautical activities at the expense of aeronautics for the civilian applications, as well as science and applications. That is an issue and a theme that you will see running through these hearings this year, that is, why in the world are these other activities of NASA that are outlined by the Space Act being sacrificed for items that clearly are related to national defense, and that the national defense establishment does not seem to be willing to invest in.

Senator Cannon?

Senator **Cannon**. Thank you, Mr. Chairman.

I certainly join Senator Schmitt in my concern that you have, to me, completely disregarded the intent of Congress, particularly what was directed with respect to the aeronautical area. Now, I wrote you a letter on February 3, which finally was answered just yesterday afternoon, but in that letter I quoted as follows from the report of the Senate authorizing committee in an executive committee session of May 6:

> It is the intent of the committee that $51.2 million of these added funds be applied by NASA for enhancement of selected activities previously summarized in the discussion of systems technology programs. Particularly the following technology programs should be enhanced or accelerated to permit the aviation industry to retain technological leadership in both near and long-term activities which are under most intense competitive pressure from foreign industry consortia: Advance turboprop, advanced aircraft composites, high speed aircraft technology, computer aircraft technology, critical aircraft resources, active controls technology, and laminar flow control technology.

Let me ask you, did you follow out that direction of Congress in your plan?

Mr. **Beggs**. No, sir, we didn't, on a number of those specific items, Senator Cannon. Again, the general philosophy we followed was that we should continue on a sustaining basis the technology and the research work, but that we should cut back and, indeed, in many areas, eliminate the systems technology and the demonstration work or validation work that had previously gone on in those areas.

I think you will find in the details of the program that what we did was to go in and take out those programs which involved hardware and validation of technology and concepts on the assumption and the philosophy that those areas would be picked up by the industry and that, assuming that they were actively interested in producing a product from that technology, they would take on the validation work.

Senator **Cannon**. When you say on the assumption that they would be picked up by the industry, have you had any indication in the past 3 months that our aviation industry could or would, to any substantial degree, itself provide the risk investment for these technology development programs being curtailed by NASA?

Mr. **Beggs**. No, sir, I have not. On the other hand, it has been a short time since our plans were published. I think, it would be unlikely that we would get a response from the industry as yet. As I mentioned in my statement, Senator Cannon, we are in the midst of an aeronautical study at the OSTP. One of the issues that is before that study group is just this question. Whether there is, in the industry, a sufficient resource as well as willingness to go forward to do that hardware work. The fiscal year 1982 operating plan and the fiscal year 1983 budget were developed with that in mind; that is, that the study would go forward and that answers to those questions would be forthcoming.

Senator CANNON. In your letter of yesterday afternoon you say:

> In the fiscal year 1983 budget review and decision process, the final determinations were that NASA funding for these demonstration efforts should be brought to an orderly conclusion and that the private sector aviation industry should determine which of these efforts warrant continuation of funding by the private sector.

Now, is that consistent with what Congress told you, as specifically spelled out, is the intent of Congress?

Mr. BEGGS. What the committee told me to do, as I understand it, was to fund a number of very specific studies in very specific research and development activities, and I am cognizant of that instruction. However, as we know, toward the end of the session there was an across-the-board cut leveled on the agency. As I stated earlier, our decision was to include those cuts by appropriation accounts and to adjust the line items within the appropriation accounts. That is the philosophy we have followed.

Senator CANNON. Thank you, Mr. Chairman.

Senator SCHMITT. Mr. Beggs, I recognize the difficulty of absorbing across-the-board cuts. But it would seem to me that it has been used—the administration has used this, and maybe most specifically, the Office of Management and Budget has used this as an excuse to ignore what Congress judgments have been in determining NASA's priorities.

It also seems to me conceptually to ignore that aeronautics research and technology is one of the few areas of sustaining research technology development that the Federal Government has ever entered into that has been totally successful.

American aluminum flying through the air dominates the world market because of the success of the NACA and subsequent NASA efforts. The only other major sustaining research and technology effort of such a successful magnitude that I can think of right now is the agricultural effort undertaken by the land-grant colleges. They are entirely different but they have been successful, and in both cases the administration's budget says we are not going to do that any more. We are going to let the private sector undertake it and somehow or another, pick up the slack without any clear justification that it will happen.

I am not going to prolong this discussion, but clearly there is a major difference in concept between this administration, the budget people anyway, and the Congress, and we will be dealing with that in very specific ways as we mark up the NASA budget.

Mr. BEGGS. Mr. Chairman, I might add one comment; I agree with what you have said. Without any question, the aeronautics program for 6 or 7 years has been extraordinarily successful in moving this country ahead thereby making us preeminent in aeronautics throughout the world, most particularly in civil aviation. However, it has also had a dramatic effect in making our military aircraft the best and most superior aircraft in the world.

I did go back and read some history, though, with respect to the NACA. It makes interesting reading because in the early days the NACA—in the late 1920's and early 1930's—they would very carefully instruct the NACA laboratories that they were not to get into what they described as competitive aircraft programs, which was strictly circumscribed as including demonstration projects. And in a sense, what has been proposed here is doing just that.

The point I want to make is this: The research and technology [R. & T.] base that we did leave untouched in fiscal year 1982 has actually increased by a small amount, maybe $5 million. Again, the philosophic argument, I think, is that we took out the demonstration projects.

Senator **Schmitt**. That is not entirely clear, Jim. We will get into this in more detail as we study the budget, but it seems to me that many of the things that are being terminated are the kinds of things that have provided the basis for Government, industry, and academic cooperation at a sustaining research and technology level, not a demonstration level. Nobody is arguing that NASA ought to go out and build airplanes, but it does provide a unique umbrella under which the industry and the Government can cooperate in developing new technology, ideas, and systems.

I just fail to see how you really have followed the basic intent of the Space Act and the basic intent of Congress under that act in these kinds of cuts, not only here but unfortunately in other parts of the budget.

Mr. **Beggs**. Yes, sir.

Senator **Schmitt**. And we will be discussing that in considerable detail. What inflation rate has been assumed in this fiscal year 1983 budget?

Mr. **Beggs**.The most recent figure we have had given to us is 7 percent, Mr. Chairman.

Senator **Schmitt**. That is what the budget presented to us is based on? A 7-percent inflation rate for fiscal year 1983?

Mr. **Beggs**. When we were developing the budget, I think it was higher.

Senator **Schmitt**. And do you have a measure of the inflation rate that you have been experiencing over the last year or so?

Mr. **Beggs**. Yes; it has been on the order of 9 to 11 percent.

Senator **Schmitt**. That is the aerospace inflation rate? I realize that the CPI is about this number.

Mr. **Beggs**. The short answer is "Yes," but the long answer is complex. We develop an index based upon a number of factors within the industry, and ours would, I think, be a little different than that which is developed over in the DOD.

Senator **Schmitt**. But has the aerospace inflation rate been declining at roughly parallel to the decline of the CPI?

Mr. **Beggs**. Yes; but it is higher. It has been declining at a rate a little bit higher.

Senator **Schmitt**. Two points, three points higher?

Mr. **Beggs**. A point and a half to two points.

Senator **Schmitt**. If you have more specific information to submit to the committee, we would appreciate it.

Mr. **Beggs**. Yes, sir. I certainly will.

Senator **Cannon**. Your budget proposal for 1983 retains only two systems technology programs, both clearly oriented toward military needs. As your statement explains, it eliminates entirely seven systems technology programs oriented toward civil commercial needs. Now, how do you reconcile that to your stated commitment to support commercial needs which are as dependent upon those systems technology programs as are the military needs?

Mr. **Beggs**. With regard to the military, we have, over the years, attempted to take our technology to the point where the military would have a solid base to go out and immediately develop an operating aircraft. That has been carried on as long as I can remember, as long as I have been in the industry. NASA developments have been flown, and then turned over to developers and manufacturers in a state where we feel, with a high degree of confidence, that they can be applied to an operating aircraft. What we are saying with respect to the commercial side is that we are going to back away from that level of technology development and turn the responsibility over to the manufacturers to complete the final development work on their own before it would be incorporated in a commercial aircraft. The prospect of whether it will be successful is perhaps too early to judge. If it is not, I think that we have got to reconsider. If the industry is as capable as we think they are, then they ought to be able to pick it up.

Senator **Cannon**. But you have no indication that they might pick it up.

Mr. **Beggs**. No, sir, we do not.

Senator **Cannon**. And that approach is clearly contrary to the intent that Congress has expressed so far.

Mr. **Beggs**. Yes, sir.

Senator **Cannon**. And since my letter to you of February 3, it is my understanding that NASA found a potential saving of $17 million on the fiscal year 1982 operating plan, redefinition of the solar maximum program, and it is my understanding that you do not propose making that money available for aeronautics. You transferred that to the Shuttle program; is that correct?

Mr. **Beggs**. That is correct, sir.

Senator **Cannon**. Well, I must say, I am very disappointed. I am quite upset that you and the administration through you just completely ignores what Congress spells out as its intent quite clearly, and I must say that I am not happy with it. I am not proposing that I'm going to accept it if I do not have to. I'm going to try to do something about it. So I just want to put you on notice as to that. Thank you, Mr. Chairman.

[The letters referred to and relevant material pertaining thereto follow:]

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, D.C., February 3, 1982.

Mr. JAMES M. BEGGS,
Administrator, National Aeronautics and Space Administration,
Washington, D.C.

DEAR MR. BEGGS: My reaction to NASA's operating plan for FY 82 can best be summarized by one word—disbelief. During the twelve Congresses since its inception, NASA program funding has been characterized by a strong bipartisan approach in the Authorization and Appropriations Committee in close cooperation with the Administration and NASA. The consensus there achieved has provided the foundation for the Nation's most rewarding and sustained record of success of any national endeavor. Never before now, however, has the will and the intent of the Congress in this area been so disregarded by any Administration, Republican or Democrat, as it now is in this proposed operating plan.

For example, in our Senate Authorizing Committee Executive Session on May 6, 1981, the Committee in an overwhelming non-partisan vote of 13-3 approved a $51.2

million increase in the authorization for Aeronautics Research and Technology. Senate Report 97-100 made clear the Committee's intent in this matter as follows.

"It is the intent of the Committee that $51.2 million of these added funds be applied by NASA for enhancement of selected activities previously summarized in the discussion of the systems technology programs.

"In particular the following technology programs should be enhanced or accelerated to permit the aviation industry to retain technological leadership in both near and long-term activities which are under most intense competitive pressure from foreign industry consortia.

"Advance turboprop (or prop-fan); Advanced aircraft composites; High Speed Aircraft Technology (Aerodynamics, materials and propulsion); Commuter Aircraft Technology; Critical Aircraft Resources; Active Controls Technology; and Laminar Flow Control Technology."

The Senate Appropriations Committee, independently responsive to the same national needs, provided $45 million additional funding for essentially the same systems technology programs.

The Committees of Conference for both the Authorizing and Appropriations Committees also made their positions clear. Conference Report 97-351, filed by Mr. Fuqua, authorized an increase of $20 million "above the revised request to be used for acceleration of advanced turboprop technology, large composite primary aircraft structures, high speed transport technology (structures, aerodynamics and propulsion), commuter aircraft technology, critical aircraft resources, active controls technology, and exploratory or feasibility studies pertaining to a possible future numerical aerodynamic simulator."

Conference Report 97-222, filed by Mr. Boland appropriated an increase of $70 million for specified areas, including aeronautical research and technology, with the conferees directing "that additional funding be applied to each of these areas in such a manner and in such amounts as to bring about a meaningful programmatic enhancement of each of these programs." I hardly need repeat here the conviction of the joint Authorizing and Appropriations Committee that our aviation industry's worldwide commercial leadership and the multiple economic returns to our economy in the form of employment, foreign trade balance and tax revenues are at risk.

Apparently oblivious to those clear indications of the will of the Congress, your operating plan reflects a reduction of $52 million from the level authorized for Aeronautics Research and Technology in P.L. 97-96, a level amply supported by the aforementioned additional $70 million appropriated for NASA's R&D. That reflects a decrease of at least 18% in an account and programs for which the Congress authorized and appropriated funds for significant increases in those programs. I consider it unconscionable to justify that position by a strained reading of the intent of H.J. Resolution 357 which limits reductions by the Administration to 5% "for each appropriation account, activity, program and project . . ." with no formal or informal effort made to contact Congress to clarify its intent if the same was in any way in doubt.

The above action is further exacerbated by allocating in the FY 82 operating plan $35 million for a Satellite Retrieval and Repair Mission not previously considered by this Congress. Regardless of the judgment which the Authorizing Committees of the Congress may subsequently come to on this mission, the foregoing reapportionment of funds authorized for other purposes clearly preempts Congressional will and authority expressed in Sec. 4(3) of P.L. 97-96.

It is distressing to me and a number of my colleagues to contemplate this clear disregard of a specific Congressional mandate in the budgeting process for an Agency which has commanded the bipartisan respect of twelve successive Congresses (in all of which I have served) since its establishment. It is my earnest hope that you will take appropriate steps to revise and bring your FY 82 operating plan into harmony with what you and I know to be the intent of Congress in this matter as conveyed in Public Laws 97-96, 101 and the relevant Committee and Conference Reports. This means an apportionment of no less than $271 million (285—5%) for Aeronautics R&D and to request supplemental authority and appropriations for programs not previously considered by the Congress.

With best wishes, I am

Sincerely,

HOWARD W. CANNON.

National Aeronautics and Space Administration,
Washington, D.C., February 22, 1982.

Hon. Howard W. Cannon,
Committee on Commerce, Science, and Transportation,
U.S. Senate, Washington, D.C.

Dear Senator Cannon: Thank you for your letter of February 3, concerning the NASA FY 1982 Operating Plan. As you are aware, the FY 1983 budget request and the related 1982 Operating Plan reflect a policy in Aeronautical Research and Technology significantly different from that on which the original FY 1982 budget plan was based. For a number of years, NASA has been involved not only in fundamental research and technology but also in funding of carefully selected systems technology demonstrations, many of which have been oriented toward application in commercial transport aircraft. In the FY 1983 budget review and decision process, the final determinations were that NASA funding for these demonstration efforts should be brought to an orderly conclusion and that the private sector aviation industry should determine which of these efforts warrant continuation of funding by the private sector. The NASA budget, however, continues a strong emphasis on providing the research and technology base for both civil and military aviation and on conducting selected systems technology activities relevant to national security. The resultant funding plans are $233 million in FY 1982 and $232 million in FY 1983.

For Space Transportation activities, the FY 1982 Operating Plan provides $3090 million, $46 million less than the March amended budget request. I believe this to be the minimum level consistent with the priorities which the Congress and the Administration have placed on the Space Shuttle program. The Operating Plan and budget are geared to completing the Shuttle development flight test program in FY 1982, delivering the orbiters on the approved schedules, and beginning operational missions in early FY 1983 with a total of 32 flights through FY 1985. It is our judgment that a lower flight rate would erode the confidence of both national security and commercial users of the Shuttle to the point where they would feel compelled to acquire alternative launch capabilities.

The demonstration of the ability to retrieve/repair a satellite, included in the FY 1982 Operating Plan, is clearly a high priority activity in establishing the Shuttle's operational capability. We have carefully reviewed the planning for the proposed mission to retrieve and repair the Solar Maximum Mission spacecraft and have adopted a changed mission approach which will permit the reduction of FY 1982 funding requirements from $35 million to approximately $18 million. Enclosed for your convenience is a copy of our letter dated February 19, 1982, which explains in detail our current planning for this mission.

In summary, formulation of the FY 1982 Operating Plan has been a difficult process because of the need to resolve a number of divergent demands and constraints. We believe that the plan as presented reflects a reasonable effort to reconcile these demands and that the plan has been presented in a manner which readily identifies the major policy issues. We believe that any significant increases in funding in the area of Aeronautical Research and Technology could be made only with a serious impact on the Space Shuttle program. For these reasons, we urge your support of both the FY 1983 budget and the related Operating Plan for FY 1982.

Sincerely,

James M. Beggs,
Administrator.

December 15, 1981.

Hon. Malcolm Baldrige,
Secretary of Commerce,
Department of Commerce,
Washington, D.C.

Dear Mr. Secretary: It occurs to me that you may not be fully aware of the critically negative effect on our foreign trade balance and the national economy that is likely to result from OMB's proposed elimination of NASA's aeronautical systems technology programs and curtailment of its technology base.

As recently as 1980 our aviation industry's net contribution to our foreign trade balance was about $13 billion, leading all manufacturing industries, and perhaps even agriculture. That achievement was made possible by our aviation technology leadership largely attributable to NASA's technology base and most specifically to its aeronautical systems technology programs. These programs are carried out through a model of many years standing featuring shared government, industry and university research and development coordinated and largely funded by NASA. For the FY 1982 budget, the Congress has authorized $284 million for NASA's Research and Technology of which about one half would be allocated to those programs. You will have little trouble seeing how great are the returns to the national economy for so small but essential an investment of public funds.

If you share my concern over this apparently misguided proposal of the OMB, you may care to reflect that view to the President or to the counsellor to the President. With foreign consortia of government and industry now challenging our aviation technology and marketing accomplishments, we will be faced not only with serious loss of foreign aircraft sales within this decade, but the prospect of major purchases by U.S. airlines of foreign transport aircraft.

The proposed reduction for NASA's aeronautical R&D can hardly, therefore, be viewed as a step toward strengthening the national economy.

With best wishes, I am

Sincerely,

Howard W. Cannon.

The Secretary of Commerce,
Washington, D.C. February 24, 1982.

Hon. Howard W. Cannon,
U.S. Senate,
Washington, D.C.

Dear Senator Cannon: Thank you for your letter concerning the value and contribution to our economy made by the NASA aeronautical systems technology programs.

I am concerned about the increasing foreign challenge to our technology leadership. The Cabinet Council on Commerce and Trade has recently directed a study on the competitiveness of our high technology industries, including the aerospace industries.

The current budgeting situation is placing constraints on the funding of many programs, including the programs at NASA. The President's Office of Science and Technology Policy has a study group reviewing the NASA aeronautical programs budget and the role such programs play in the long-term goals for our economy and our international competitiveness.

When the above mentioned studies are completed, we will be in a better position to respond.

Sincerely,

Mac Baldrige
Secretary of Commerce.

Senator Schmitt. Thank you, Senator Cannon.

One further thought comes to mind on this, Jim. Did you take a look at the antitrust protection that industry has working with NASA in making this decision and whether or not the absence of this protection when they have to do it on their own, in any way inhibits their activities?

Mr. Beggs. That question was briefly discussed, Mr. Chairman, but not examined. I cannot say that we really got into the antitrust.

Senator Schmitt. Can you ask your General Counsel to give us, through you, obviously, a discussion of just how important the effective antitrust protection is when industry works with NASA in the aeronautics area?

Mr. Beggs. I sure will.

[The following information was subsequently received for the record:]

National Aeronautics and Space Administration,
Washington, D.C., April 1, 1982.

Hon. **Harrison H. Schmitt,**
Chairman, Subcommittee on Science, Technology and Space, Committee on Commerce, Science, and Transportation, U.S. Senate, Washington, D.C.

Dear Mr. Chairman: During my testimony before your Subcommittee on February 23, 1982, you requested that the NASA General Counsel provide me, and that I in turn provide you, with a discussion on antitrust protection available under NASA/contractor relationships which, by implication, might not be available in the absence of a NASA presence.

In response to your request, I am enclosing a copy of the General Counsel's submission to me. You will note that the overall subject is generously addressed in the "Antitrust Guide Concerning Research Joint Ventures" prepared by the Antitrust Division of the Department of Justice which is attached to the General Counsel's memorandum.[1]

I believe that the various complexities of this subject are easily recognized from even a cursory perusal of the guide. Noteworthy in this regard is the coverage beginning on page 56 which demonstrates potential pitfalls which can arise even in connection with Government assisted basic research. However, I do not believe that such pitfalls would be encountered in a normal NASA/contractor contractual relationship.

I trust that the enclosed information is responsive to your request.

Sincerely,

James M. Beggs, *Administrator.*

Enclosure.

March 5, 1982.

To: A/Administrator.
From: G/General Counsel.
Subject: Response to request by Chairman Schmitt regarding certain antiturst matters.

During your testimony on February 23, 1982, before the Senate Subcommittee on Science, Technology and Space, the subject of antiturst protections was introduced by the Chairman. The context within which the subject arose was with regard to NASA's reorientation of certain programs and projects whereby basic research and development would continue to be pursued by NASA but final technology development, demonstration, and commercialization would be carried out by the private sector.

You had previously been asked during your testimony whether there were any signs that the private sector was prepared to pick up where NASA left off after curtailing its work in these areas. The follow-up questioning later by the Chairman on the antitrust issue appeared to be aimed at whether or not the private sector would be inhibited by antitrust concerns to the point that technology development work which otherwise would have been pursued jointly by NASA and its contractors would no longer be pursued when NASA curtails its participation.

As a result of the various exchanges, Chairman Schmitt requested that my office provide you, and through you to the Chairman, "a discussion of just how important the effective antitrust protection is when industry works with NASA in the aeronautics area." You agreed and this is in response to your agreement.

It should first be noted that a question of this nature is as broad as it is long. Joint undertakings properly structured with a private sector entity or entities whereby NASA is a contracting "partner" in general have not given rise to substantive antitrust issues. In my view, no further discussion of this side of the coin would be fruitful. The other side of the coin may or may not be fraught with complex antitrust issues depending upon the circumstances. As I understand the thrust of the Chairman's question, his concern centers around circumstances which would arise when NASA as a contracting partner is replaced by a private sector entity in "partnership" with another private sector entity to pursue a technology development no longer being pursued by the federal government. Such "partnerships" could be in the form of a joint venture, consortium, or other form of teaming arrangement.

It goes without saying that NASA is not charged with the responsibility of enforcing the antitrust laws and, therefore, any opinions offered on real or hypothetical situations would not be authoritative. For this reason, we are reluctant to postulate potential scenarios and venture opinions on which ones would or would not likely result in antitrust violations. This sort of activity is better left to those who have the expertise in these matters, i.e., the Antitrust Division of the Department of Justice.

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[1] The booklet referred to has been retained in the committee files.

It is probable that the Antitrust Division would prefer to address real cases and not hypothetical ones. However, we are aware that they have prepared a guide which sets forth in detail the Division's general approach to such matters. It is entitled "Antitrust Guide Concerning Research Joint Ventures" and was published in November 1980. A copy is attached. As far as we know, this is the latest edition of the guide and is presumably still the current guidance of the Antitrust Division. In my view, the best and most direct response to the Chairman's request for a discussion on the potential antitrust issues is to forward the guide to him. I recommend that you do so.

However, I would direct his attention to page 1 of the guide where it is stated: "The intensity of antitrust concerns about joint research will vary along the research spectrum: less intense about 'pure' basic research, undertaken without ancillary restraints on use of the results, to more intense at the developmental end of the research spectrum, particularly if ancillary restraints are involved."

In addition, a reading of Case B which is a case study in the aeronautics field and Case F dealing with Government assisted basic research may be helpful in understanding the complexities involved in antitrust determinations.

S. NEIL HOSENBALL.

Enclosure.

CASE F—GOVERNMENT-ASSISTED BASIC RESEARCH

Synthetic fiber processing (SFP) is a sizeable U.S. industry, composed of about 30 firms. Although none of these firms possesses a market share greater than 7 percent, the firms vary greatly in absolute size. A number of them are large conglomerate firms which engage in many lines of business other than SFP. Others are smaller and less diversified in their operations.

SFP is a field in which there are substantial technological opportunities, but it is also a field in which these opportunities are not being exploited because none of the current participants engages in research to the extent necessary to make significant advances in SFP technology. The large firms justify their lack of interest in research in this area by pointing to the relatively low profits that can be earned in the field and the presence of research projects in other fields that offer greater probability of paying for themselves and providing profits. The smaller firms do not engage in research because they simply cannot afford to invest the large sums they believe would be needed for effective programs. Due to the technological backwardness of the American SFP industry, foreign firms have captured a small but steadily growing share of the market.

Professor M. A. Smith of the Banneker Technological Institute (BTI) proposes a solution to the lack of research in the STP industry that he believes will not only aid the firms in that industry but will also benefit BTI by providing students an opportunity to work on important and unresolved problems in synthetic fiber technology. He approaches the U.S. Research Fund, (USRF), a government agency devoted to promoting research, to obtain funding for his project. This project, the BTI—SFP Industry Cooperative Program ("the Program") will consist of two parts: (1) a feasibility study, which will last no longer than one year, and (2) actual research to be performed by BTI with funds provided by USRF and industry participants. If industry support is forthcoming, the second phase of the Program will continue for a number of years.

The feasibility study will determine whether BTI faculty, students, and administration are willing to participate in the Program to the extent necessary to make it workable, and will also determine whether members of the SFP industry will provide financial support for the Program. USRF will provide 90 percent of the funds needed to pay for the feasibility study, BTI the remaining 10 percent.

The actual research will have the following features:

(1) Funding: USRF will provide a substantial grant to get the program off the ground. This grant will be in an amount sufficient to pay for 75 percent of the anticipated costs in the first year of operations, 50 percent in the second year, 25 percent in the third, and 10 percent in the fourth. It is anticipated that, if the Program is successful, all remaining funds plus the funds necessary to continue the Program past the fourth year will be provided by industry participants. If this support is not forthcoming, the Program will be terminated.

(2) Membership: Membership will be open to any business enterprise. Any firm wishing to participate must commit itself to remaining a member for at least two

years and any renewal of membership must be for at least two years. (This is felt to be necessary to insure an adequate cash flow to continue the Program). Because of the history of lack of interest in research in this industry, it is contemplated that there will initially be great difficulty in persuading SFP firms to join the Program and that no more than 3 or 4 firms will join during the first two years of operation. Assuming that the Program is successful in producing results, it is anticipated that as many as eight or nine firms in the SFP industry will have joined by the end of the initial four years of operation.

(3) Membership fee: The membership fee will usually be based on synthetic fiber sales. Any SFP firm wishing to join will be required to submit to the Project's outside accounting firm its synthetic fiber sales for the past year. The accounting firm will then bill the member firm a fee based on its sales of synthetic fibers. Any firm outside the SFP industry that wishes to participate must pay an amount equal to that which would be paid by a firm which made 2 percent of U.S. synthetic fiber sales. (The use of this minimum amount is justified on the basis that unless there were some such minimum, outside firms would be able to obtain patent and know-how rights from the venture, as explained subsequently, without having to bear their fair share of costs of the Program).

(4) Organization: Professor Smith is to be director of the Program. He will choose which projects are to be pursued, based on the technical merits of the project and on industrial needs. In making this choice he will evaluate: (a) long-run needs of the SFP industry, (b) specific needs of the participant firms, and (c) the educational value and intellectual challenge of the projects. Professor Smith will also oversee all work, decide the direction projects will take, and decide whether projects are to be continued or terminated.

Individual projects will be supervised by BTI faculty members and post-doctoral fellows, although the day-to-day work on projects will be pursued by graduate students who will be using the projects to develop material for master's theses and doctoral dissertations.

Professor Smith will be assisted in his supervisory duties by a Committee of Advisors. The initial membership of this Committee will be chosen by Professor Smith: replacements for original members who leave the Committee will be chosen by the Committee membership. The Committee will have eleven members, four will represent participant firms, four will be from USRF, two will be from the BTI faculty or administration, and the final member, and chairman, will be Professor Smith.

(5) Patents and Know-How: All inventions and useful know-how developed in the course of the Program will be promptly reported to BTI, USRF, nad the participant firms. BTI will apply for patents on all patentable inventions, and will retain title to all inventions, patents and know-how. Any firm that is a participant at the time an invention or know-how is discovered, and USRF, will receive irrevocable, royalty-free, nonexclusive licenses on all patents and know-how developed. (The obligation to inform USRF of inventions and advances in know-how, and the obligation to license USRF on all patents and know-how would cease upon the conclusion of the four years of federal financial aid to the Program).

No later than one year after the participants receive the foregoing licenses, licenses will be made available to outsiders on reasonable and nondiscriminatory terms. Income from those licenses will be divided among BTI and those firms which participated in the Program at the time the invention or knowhow was first reported.

(6) Publication of Results: Because BTI is an educational institution and because publication may advance the careers of the students and faculty who perform the research, it will be the policy of the program to make public the results of the research performed through presentation of papers at conferences and through publication in scientific journals. Publication may, however, be delayed up to one year after the results are reported to the participants to allow time for the participants to exploit the news ideas.

DISCUSSION

The BTI-SFP Industry Cooperative Program presents two basic questions: (1) what effect, if any, does government involvement have on the legality of joint research in general and on the legality of this Program in particular? and (2) assuming that government involvement does not preclude application of the antitrust laws to the Program, does the Program violate those laws because of effects of its essential elements or its collateral restraints, or because of restrictions on access to the Program's results?

Government involvement in research joint ventures, like government involvement in any other business activity that may have anticompetitive consequences, is a complex subject. If the United States or one of the States, "as sovereign, impose[s] the restraint as an act of government," that restraint cannot be called into question under the Sherman or Clayton Acts.[1] Similarly, many federal statutes allow federal agencies to immunize activity otherwise subject to antitrust laws by approving that activity.[2] While most of these immunities are in the area of regulated industries, some are not.[3]

Finally, some federal statutes impose on private parties certain duties fulfillment of which requires that the parties be immune from the antitrust laws. In this situation, immunity from the antitrust laws is implied "only if necessary to make the [federal statutes] work, and even then only to the minimum extent necessary".[4]

There are other forms of government involvement, however, that confer no antitrust immunity on private parties. Mere knowledge of government officials that private parties are pursuing a particular course of action, or tacit approval of that course of action, provides no excuse for conduct contrary to the antitrust laws.[5]

The involvement of government in the BTI-SFP Industry Cooperative Program plainly goes far beyond mere knowledge or tacit approval of that Program. The government is a partner in the Program: it provides much of the funding, it is represented on the Committee of Advisors, it shares in the results of the research. At the same time, the Program cannot be said to be immune from the antitrust laws because it is compelled by government: any SFP firm is free not to participate in the Program, and any firm that participates in the Program is free to withdraw after an initial two-year involvement. No statute empowers USRF specifically to immunize conduct of the Program from the antitrust laws.

There remains the more difficult question: do the statutes creating USRF impose duties on the Program the fulfillment of which requires that it be immune from the antitrust laws? It is safe to assume that the legislation creating USRF intended to impose upon those receiving money from the Fund certain duties, including the duty to make good-faith efforts to achieve substantial innovation.

However, there is no inconsistency here between the goals of greater innovation and the antitrust laws. As this Guide has emphasized, increased innovation and increased competition are complementary, not antithetical, goals. Finally, participants in research projects supported by USRF are not subjected to inconsistent standards which make it impossible for them to act without risk of violating the law.[6] Thus the antitrust laws apply to the Program in spite of substantial government involvement in it.

That the antitrust laws apply does not, of course, necessarily mean that they forbid any or all of the conduct in question. Indeed, in the case of the Program, all of its aspects and details appear to be consonant with the antitrust laws.

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[1] *Parker* v. *Brown* 317 U.S. 341 352 (1943). As elaborated in later decisions, the *Parker* v. *Brown* immunity only applies where the restraint is "one clearly articulated and affirmatively expressed as state policy," and where that state policy is "actively supervised" by the State itself. *Cal. Retail Liq. Dealers Ass'n* v. *Midcal Aluminum, Inc.*, 445 U.S. 97, 105 (1980), quoting *City of Lafayette* v. *Louisiana Power & Light Co.*, 435 U.S. 389, 410 (1978) (opinion of Brennan, J.). While *Parker* v. *Brown* applies by its terms only to action by one of the States, the implied immunity it embodies is equally applicable to federal action compelling a certain course of conduct. Since, as explained in the text, federal action which does not rise to the level of compulsion may give rise to implied immunity, it follows a *fortiori* that federal compulsion would create antitrust immunity for the conduct compelled.

[2] See, e.g., 49 U.S.C. § 1384 (consolidations, mergers, acquisitions of control, interlocking relationships, pooling agreements of air carriers subject to CAB jurisdiction); 46 U.S.C. § 814 (rate agreements among water carriers subject to FMC jurisdiction).

[3] An example is 15 U.S.C. § 638(d), which provides a method for the Small Business Administrator, after obtaining the written consent of the Attorney General, to exclude small business joint research and development programs from the operation of the antitrust laws.

[4] *Silver* v. *New York Stock Exchange*, 373 U.S. 341, 357 (1963); *Gordon* v. *New York Stock Exchange*, 422 U.S. 659, 685 (1975).

[5] *United States* v. *Socony-Vacuum Oil Co.*, 310 U.S. 150, 226 (1940); *Union Carbide & Carbon Corp.* v. *Nisley*, 300 F. 2d 561, 577 (10th Cir.), *dismissed sub nom. Wade* v. *Union Carbide & Carbon Corp.*, 371 U.S. 801 (1962). In the latter case, the court held that the defendants could not rely on the fact that they were acting as agents of the government in purchasing vanadium ore to justify a conspiracy to restrain trade in vanadium, since there was no showing that the government intended to require, or even authorize, the restraint of trade.

[6] That the New York Stock Exchange was subject to the possibility of having to comply with two sets of legal standards (the Securities Exchange Act and the antitrust laws) which might be inconsistent with each other was the principal reason why immunity from the antitrust laws was implied in *Gordon* v. *New York Stock Exchange*, 422 U.S. 659, 689-690 (1975).

First, there do not appear to be anticompetitive effects from the essential elements of the Program. During its initial stages of operation the Program is not expected to have the support of more than four firms out of thirty in an unconcentrated industry. Even if Professor Smith is successful in recruiting as many as eight or nine firms to support the Program, a majority of firms in the industry will still be nonparticipants. In these circumstances, the possibility of the participant's being able to control the pace of innovation in the industry is not very great.

Second, it is obvious that the Program offers a great deal more promise of innovation than would be the case in the absence of a program. At present, there is no significant SFP research being conducted. The program offers some hope of changing that by (a) making significant discoveries in SFP technology by itself, (b) demonstrating to participants the opportunities for innovation in the field, thus encouraging them to engage in research on their own, and (c) exerting competitive pressure on nonparticipants to engage in research. Clearly the program promises to encourage innovation rather than to retard it.

Finally, the involvement of BTI and USRF and the structure of the Program make suppression of innovation extremely unlikely. Because BTI and USRF play such leading roles in the research, and because both are strongly oriented toward success in innovation, there is little likelihood that the participant firms can retard innovation individually or collectively by dragging their feet.[7]

Neither of the collateral restraints imposed on the participants gives rise to serious antitrust concern. The first of these, the two-year minimum period for initial or renewal memberships of industrial participants, seems quite reasonable as a means of assuring that participants are seriously interested in funding such a program, and in making it possible to plan and budget research with the assurance that the money needed will be forthcoming. This restraint also has the incidental benefit of making it difficult for participating firms to seek to control the rate of innovation by threatening to withdraw support. The second collateral restraint, the delay of up to one year before researchers can publish their results, also seems no broader than necessary to protect the interests of the industrial participants, and to assure their continued participation. If results were to be published at once, and no lead time permitted for participants, there would be less incentive to invest in the Program.[8]

Restraints on access to the Program and to the results of the Program do not present antitrust problems. Any firm can join the Program upon payment of a relatively small fee, and the fee is adjusted to reflect the synthetic fiber sales volumes of the participants. The minimum fee for firms outside the SFP industry, which amounts to only 60% of the average fee for firms within the industry, is not unreasonable. Without some minimum fee in excess of a purely nominal amount, SFP industry members may be reluctant to participate in paying substantial sums to fund research, only to have the results of that research "given away" to firms outside the industry which have joined the Program. There is similarly nothing objectionable about the patent and know-how licensing provisions. Anyone is free to buy a license and anyone will be able to obtain a license on reasonable and nondiscriminatory terms. The one-year delay in making licenses available is lawful for the same reason that the one-year delay on publication is lawful—both serve to encourage participation in the Program, and both are so limited in time that they do not enable the firms participating in the Program to sit on new developments and thus impede innovation.

Government-assisted research is frequently an important contributor to technological progress. As this case shows, it is not difficult to structure such a research program so as to avoid potential antitrust pitfalls.

Senator **Schmitt**. In previous years NASA's projected budgets have included a new start wedge. Is this included in any of the 1983 projections?

Mr. **Beggs**. No, sir, it is not. We took out any new start wedge in the outyears. There is none projected in the figures that we have sent out.

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[7] In view of these considerations neither the fact that many SFP firms might eventually join the Program, nor the fact that the Program may extend over a long period of time, raises the same sorts of antitrust concerns that these facts would raise in the context of a program in which all decisions of importance were made jointly by the participating firms.

[8] See the discussion of "predisclosure" in *Berkey Photo, Inc.* v. *Eastman Kodak Co.*, 603 F. 2d 263, 279-285 (2d Cir. 1979), *cert. denied*, 444 U.S. 1093 (1980).

Senator SCHMITT. Does this imply that the Shuttle wedge is a way to save money in the future in the overall budget?

Mr. BEGGS. No; my understanding with the OMB is that this was done without prejudice as to potential new starts in the future, but the runouts are based upon the current program.

Senator SCHMITT. You believe that, and I will sell you some land on the Moon.

Mr. BEGGS. I'm not all that pessimistic about the future. I think there is a potential of putting in some new start money.

Senator SCHMITT. I'm not either. I think you're going to be under increasing pressure from the Congress and the public not to do what the OMB green eyeshade wearers would like us to do, and that is to cut research and development and research and technology wherever it is possible to do so, in order to be able to keep money flowing in other areas. This country just has to find a better balance than it has had in recent years between its various priorities including those for a sustaining base of science and technology.

We will see what happens.

Mr. BEGGS. This agency, as you stated in your opening statement, has demonstrated over the years that its capabilities, and the research, and technology program we have carried on have been enormously important to the Nation. I yield to no man on wanting to continue that effort. And we feel that in fiscal year 1983, we have proposed a budget which—in many of the areas of research and technology—has been increased. Again, the areas that have been decreased or eliminated are those areas which move into hardware, and that applies both to the aeronautics budget and to the space applications budget, where we have taken out certain aspects of technology programs which have been envisioned in the past as going on through a hardware demonstration. That is a philosophic basis of budgeting which, as we have discussed previously, may or may not turn out to be correct—whether the hardware demonstrations can be picked up by the industry. Our belief is that we can look forward to increasing industry participation in the future, and I hope that turns out to be true.

Senator SCHMITT. I think you can too, but before you can make the decision, you have to make sure that the ground is fertile and there is some water to put on the seed that you planted. Otherwise, you have wasted the technology—the technological development of that seed. That is what is concerning the Congress. We do not see any evidence that these programs are, in fact, going to be picked up in the present economic climate or in any economic climate. We have had some very good times when the NASA technology was obviously something that was over and above what industry was willing to do or felt that they could undertake, and I just have a feeling that your friends in the OMB had set some very arbitrary constraints and guidelines on the kinds of things that NASA can expect industry to do. It has got to be looked at on a case-by-case basis, not as sort of an overall philosophy applied to the budget.

Jim, as you know, this committee has been concerned about management problems within the agency. I am impressed by at least the paragraph that you included in your testimony, and I hope that you will continue along those lines. What have you done to implement the recommendations of the Hearth management study that was done last year?

Mr. BEGGS. Several things, Mr. Chairman. The Hearth study and report made a number of recommendations which I would characterize, basically, as getting back to fundamentals, which is very important. On my part, I have written a memorandum to all of the center directors asking them to meet with their program managers to discuss the various recommendations of the Hearth report and to work for the purpose of acquainting them thoroughly with what their responsibilities are. We have also issued a management instruction which outlines the main elements of the Hearth report. That instruction is a key part of every program and manager's responsibilities. They have been instructed that that is the bible for running their program in the future. We have held a number of meetings on the recommendations of the Hearth report. I have met with Don Hearth and the center directors to emphasize my support for the recommendation which were made. We intend to followup the recommendations that we implemented in the management instruction in about a year. Dr. Mark and I will, as we visit the centers to review individual programs, review them in light of the recommendations that were made in that report. There was one other important aspect of the Hearth report which I think bears some discussion, and that is the conclusion that they reached that we could do a better job in the initial stages of program management by sharpening our estimates and by doing a better job of procurement and contracting. We have instructed the procurement office at headquarters, as well as in the centers, that we will be doing a more thorough review of the internal estimates we make for future systems. In addition, we will be trying to be a little more innovative in the way in which we contract to put the incentives in the right place for contractors to obtain a better emphasis on cost control and management, and more emphasis on schedule, where we have perhaps not put as much emphasis as we should have in the past.

Senator SCHMITT. I presume by that you are referring to the attempts to get a more accurate assessment of cost, schedule, and technical challenge before a new program is initiated.

Mr. BEGGS. That's correct. We do have a couple of opportunities upcoming in the Shuttle effort. We will be trying to do a more effective job of incentivizing the contracts on the external tank, the lightweight SRB's, and the various and sundry activities that we have ongoing in buying consumables and finishing up the orbiters we have on order as well as looking at the potential of a block buy or blocking in a buy for Orbiter 105, assuming we get authority to go forward with 105.

Senator SCHMITT. Are you discussing that particular item with the Department of Defense?

Mr. BEGGS. We have had some discussions with the DOD on that point. But, my current belief is that we are going to be going alone on Orbiter 105.

Senator SCHMITT. We have a request in to you that has been delayed by NASA for sometime on the block-buy concept. When could we expect to get your assessment?

Mr. BEGGS. I believe we have agreed to give that to you by the early part of June, Mr. Chairman, and I think we are well on schedule.

Senator SCHMITT. Can we get a preliminary assessment earlier than that? June is quite a ways away, relative to this budget.

General ABRAHAMSON. In our testimony to you just before Christmas, sir, we mentioned that we were initiating the study. We are planning to provide an interim letter report on our progress leading to that within the next, I would say, 30 days. There are some problems with our study effort; and I will mention that in just a minute. However, the final recommendation is still planned for the June timeframe. We feel that June is consistent, with minor exceptions, with starting the Orbiter 105 program itself. If the exceptions appear to be something major, we will present those to you separately.

Senator SCHMITT. What are the particular block-buy options that you are looking at?

General ABRAHAMSON. Initially, in December, it seemed to me that combining the remaining effort into the Orbiter 104 contract with Orbiter 105 into a block buy could offer some advantages to the subcontractors. I have now seen that this would cause a major accounting problem. Since we are talking about putting Orbiters 104 and 105 together, we will use two separate contractual instruments. For example, we would look for a ceiling associated with the remaining cost on Orbiter 104. Of course, that is a cost-plus contract and a ceiling really represents, then, a firm commitment on the part of the contractor. Plus, we would be looking for more definite commitments than we have had in the past on traditional cost-plus contracting.

One of the areas where we are having trouble with is the fixed-price incentive contracting approach for our subcontractors. At your recommendation, we are adding an option for Orbiter 106 as well. So that the two basic options are now to tie Orbiter 105 to Orbiter 104 and include spares. The second and separate option would be adding Orbiter 106 to that.

Senator SCHMITT. Will that give us the ability to see what the advantages are for 107 and 108 as well?

General ABRAHAMSON. We will lay out the cost trends and contracting principles in our study effort. We should be able to make that clear. However, we are not going so far as to include Orbiters 107 and 108 at this time. We have had trouble, at the subcontractor level, getting the kinds of financial commitment I am after: but, we have the support of the Rockwell Corp. to begin negotiating down through them directly to the subcontractors. This should add some more perspective on the situation.

Senator SCHMITT. What is the level of DOD involvement in this?

General ABRAHAMSON. There have been discussions with DOD, as Mr. Beggs indicated, on the requirements for Orbiter 105. However, DOD is not now making a financial commitment.

Senator SCHMITT. Are they on an objective basis without getting into whether they are capable of making a decision regarding the need for 105 or not, working with you on the advantages and disadvantage of block buys of hardware of this kind independent of the policy decision on whether such a block buy should occur?

General **Abrahamson**. I am sorry, sir.

Senator **Schmitt**. DOD is in a shambles with respect to space policy. The last thing I would expect them to do is to make a decision on whether they need 105 or not. What I am getting at is an objective evaluation for the Congress and especially for this committee, as well as the Appropriations Committee, on which I serve, of the technical and economic advantages of a block buy of a Shuttle-type vehicle. That is what we are trying to see.

We do not know whether DOD is ever going to wake up to the advantages of having military activities in space independent of their mission on the ground. I am very skeptical right now. I do not think anybody there understands how to spell "space" much less what it is about. Probably the one person that does, now is working for NASA, and we are happy to have you.

Mr. **Beggs**. Mr. Chairman, we will try to give you an objective evaluation of the advantages of doing that. We will continue to work with DOD. I think they are becoming more responsive, maybe not as responsive as we would all like, but they are, I think, entering into joint studies and joint programs with us with an open mind.

[The following information was subsequently received for the record:]

NASA has recently completed a study effort with Rockwell International that looked at the possibilities, benefits, tradeoffs, etc. of implementing a block buy of orbiters. The study examined a block buy of OV-105 with an option for OV-106, including appropriate spares and ground support equipment. It also studied the possibility of converting OV-104 to a fixed price, incentive contract and including OV-104 as part of the block buy.

The preliminary results have indicated that a block buy as discussed is practical and will result in cost savings over a single buy approach. However, the coupling of OV-104 to a block buy does not appear advantageous.

Additional study needs to be made of a block buy approach. Should a decision be made to proceed, we would seek Congressional authority to initiate long-lead procurements in late spring/early summer 1982. Full authority to proceed with OV-105 would be given to the contractor in January 1983, assuming Administration and Congressional approval.

This schedule would allow for a delivery in August 1986.

Senator **Schmitt**. Speaking of responsiveness, how do you justify the inclusion of the IUS upper stage for launching the Galileo spacecraft and ISPM when last year, in your testimony, you fully supported the Centaur approach, and this is what Congress approved in the fiscal year 1982 budget?

Mr. **Beggs**. We tried very hard to make a joint program out of the Centaur, as the Congress directed us. We conducted a study with the Air Force last year on upper stages. We reviewed their requirements with respect to the full-sized high energy Centaur in the Shuttle. We were not able to come up with a requirement for the DOD to use such a high energy upper stage at that time. As a consequence, we went into the budget review with OMB with the total cost of the Centaur riding on two missions—Galileo and the International Solar Polar Mission [ISPM]. In a pure economic analysis, we could not justify the expenditures of money that we would have had to spend for the Centaur and Shuttle for just those two missions. Having no additional requirements, we could not go forward with it. So, therefore, we backed off to the IUS, using a Delta

Vega trajectory for the Galileo, and we lost the opportunity to put Centaur in the Shuttle.

Subsequent to that, we again entered into conversations with the Air Force to look at the potential of the short Centaur, the 20-foot Centaur and again looking at the requirements for geostationary activities, both in the DOD and in planetary and other activities for NASA. Unfortunately, the conclusion of that study again was that the DOD did not have the requirement for even that stage. Therefore, we could not justify going forward with even a short Centaur stage in Shuttle. We are, therefore, back to square one with respect to a high-energy upper stage in the Shuttle.

In the long term, there probably is a need for a high energy upper stage. The question is, How far into the future do you have to project, and when should you start the development and integration of a high energy upper stage into the Shuttle in order to meet whatever potential requirements are there in the out years?

Senator SCHMITT. In the report that was submitted to the Congress on this issue, signed by Dr. Mark and Mr. Orr, Secretary of the Air Force, the first recommendation reads as follows—and this was a November 2 submittal:

> In order to satisfy the national mission requirements/needs of both the DOD and NASA, the Air Force should continue development of production of the IUS and NASA should develop the Centaur."

That is the final recommendation and only recommendation of that report; and, Jim, your people have been very persuasive in the Air Force; and I quote now from a memorandum from Mr. Aldridge to the Vice Chief of Staff:

> Subject: Future Higher Energy Upper Stage, Action.
> Memorandum:
>
> Based on a recent thorough review of anticipated DOD payload requirements in the late 1980's and the limitations of current programed upper stage vehicles, Mr. Orr and I have concluded that the Air Force should begin the development of a higher energy upper stage for use in the late 1980's and beyond. Accordingly, please initiate a program for an fiscal year 1987 IOC of a Shuttle-compatible vehicle which will be capable of placing about 10,000 pounds in geosynchronous orbit. In the meantime, continue the minimum necessary investment in the initial upper stage program to assure that DOD payload launch requirements are met in the interim period.

Now, how in the world can we here in the Congress look at the relatively modest costs of building both a short and long Centaur upper stage compatible with the Shuttle and see the Air Force recommending the independent development of something else that provides essentially the same capability in a longer timeframe.

It sounds to me like it is not so much your problem as the Air Force's problem.

Mr. BEGGS. Let me think how I can briefly describe what was in their minds when they proceeded. Their position from the beginning, I believe, and I really should not speak for the Air Force on this, was that a high energy upper stage is required in the long term. There did not seem to be a whole lot of argument with that. I think there was some anticipation that NASA would go forward and put the Centaur in the Shuttle, in which case the point would become moot because they would have a high energy stage in the Shuttle which they could use.

When we could not sustain the development of Centaur in the Shuttle in the fiscal year 1983 budget because of economic considerations—that it was not a good financial investment for only two missions and there were no other firm requirements—I think the Air Force relooked at their requirement and said that we do, indeed, need a high energy upper stage, but the need comes at a time beyond that which is of interest to NASA.

Therefore, we had the opportunity to look at a range of options for that stage, and we should do that. That is the only interpretation I can put on that memo; having a need in the out years, they want to look at other options besides just that provided by Centaur.

Senator SCHMITT. Do you have a back-of-the-envelope estimate as to what it would cost to independently develop a new higher energy upper stage of Centaur capability?

Mr. BEGGS. I have one, Mr. Chairman. I would say well over $1 billion.

Senator SCHMITT. And to develop a Centaur short version, or even the short and long versions, would be what?

Mr. BEGGS. I should not let that single statement stand alone in the record, Mr. Chairman. That is if they start with a clean sheet of paper.

Senator SCHMITT. Won't they have to if we let the Centaur contract run out?

Mr. BEGGS. If you let the Centaur run out; but, the Centaur does have a production base, which goes out to about 1984–85. There are sufficient numbers of Centaurs on order. The RL–10 engine, I think, will be in production through late 1983 or 1984. So, there is time to pick up that engine, which is the key piece of technology; but, if you start it new, it would be well over $1 billion. The Centaur, being already developed, is of course a much lower investment.

Senator SCHMITT. What would it cost? What is the runout cost of the development of a Shuttle-compatible Centaur?

Mr. BEGGS. We have that to be about $230 million. In addition to that, you have the cost of integration into the Shuttle; I believe that adds another $125 million. So, the total is in the order of $350 million to get it in the Shuttle.

Senator SCHMITT. We will have some more questions for the record on this. I am very disturbed by it, Jim. I just do not understand why Congress should be expected to see this capability lost for Shuttle activity when the Air Force and everyone else concerned admits that they are going to need that capability and then expect somebody to come in from the other side, the DOD side, and ask for funds in order to build a high energy upper stage, whether it includes Centaur subsystems or not. It doesn't make any sense.

That does not sound like a wise budgetary policy at all. What it sounds like is that the Air Force does not want to be dependent on NASA in developing their high energy upper stage any more than they are really seriously considering the broad-scale use of the Shuttle in their future space activities.

Mr. BEGGS. In fairness to the Air Force, I should say that that study that Secretary Aldridge initiated by that memo does include NASA. We are working jointly with them in proceeding with that study, because it would involve the use of a high energy upper stage in the Shuttle. We will obviously have a responsibility for that part of the study. It is not a unilateral approach. They do envision our joining with them to define the right piece of equipment.

Senator **Schmitt**. Everywhere I look, at least in three major areas, Jim, I see the Department of Defense and particularly the Air Force sitting back and not coming up with any coherent national defense spacy policy, but saying, well, you know maybe it would be nice to have the Shuttle out there, maybe it would be nice to have a high energy upper stage out there, maybe it would be nice to have thrust augmentation. But it would be even nicer if NASA pays for all of it at the expense of space science, applications, and aeronautics.

When I look at this budget and look at the DOD commitment to space, that is what is happening. They expect you to buy all of the Shuttles. They expect you, if there is going to be a Centaur high energy upper stage, to build it. Except now we see that they think that there ought to be an upper stage but they are going to go do it on their own. Then, when we look again, and we will get into the question of thrust augmentation, it is NASA that is going to bear that cost, not the Air Force.

At the same time, you are being beat over the head and shoulders by people up here for cutting back on aeronautics, for cutting back on science and applications, for letting the rest of the world steal the march on us on the commercialization of space. It just does not make any sense. It is foolish.

It demonstrates a continuing pattern in this administration, as there has been in past administrations. We cannot seem to get coherent cooperation between the Department of Defense and NASA. I don't mean an integration. Nobody wants that, and it is not going to happen. We wouldn't have let that happen up here. But for crying out loud, at least we can recognize the compatibility of interests and cooperate in the budget as far as possible by talking to each other.

Your letter that we just received February 22 on the Centaur contract says in the next to the last paragraph:

> Therefore, to avoid unnecessary expenditures, we are taking the only responsible action, that of terminating the current contracts for a shuttle-based Centaur in an orderly manner. This will be completed by approximately March 31, 1982.

Jim, that may be a responsible action when NASA has blinders on, but it hardly seems like a responsible action for the Government when this other kind of memo is circulating within the Department of Defense. My strong recommendation to you is that you go back and try to beat some sense into them. We are going to try to beat some sense into them Thursday and see if we can't at least maintain that contract so that you all have a chance to come to some kind of a meeting of the minds on a high energy upper stage. This is ludicrous. It is absolutely ludicrous to get a letter from you saying that you are taking the only responsible action and terminating the current contract, and to see that the Air Force is circulating a memo simultaneously, saying that we need a high-energy upper stage of Centaur capability.

There is no way to justify that and I would not expect you to even try. If you want to, you can.

Mr. **Beggs**. I don't want to.

I would like to make one comment regarding the Air Force. They were very open with us throughout this discussion, and we still are discussing it. There has been no business of not talking and not discussing in detail the range of options that we both have. They know where we stand and we know where they stand. I think I understand why they are proceeding as they are. The problem that we have in the future is not solved by the way they are proceeding, but I think we understand each other, and understand why they are doing what they are doing. In short, I have no feeling that I have been left out of their decisionmaking.

Senator **Schmitt**. The problem we face over here is that we see the NASA 1982 operating plan not following the intent of Congress; we see the Department of Defense's support that now is an obligation authority is going over $250 billion, and we know that for a couple of hundred million of reimbursable funds from the Department of Defense to NASA we could maintain this year in fiscal year 1983 an extraordinarily strong aeronautics and space science program and still get everything that everybody needs with respect to shuttle procurement, with respect to thrust augmentation and the high-energy upper stage.

It is awfully hard to accept, and then when I suddenly see a memorandum where the Air Force is going off their own little independent way, after not coming forward in their budget request to support NASA in the development of the Centaur stage, it is very difficult to accept over here, Jim. And I recognize your position to some degree, I think, in this, but it is something that the Congress is going to have to resolve for the administration if we possibly can.

Senator Heflin, would you like to take a turn at questioning?

OPENING STATEMENT BY SENATOR HEFLIN

Senator **Heflin**. I have an opening statement that I would like to make, and then ask some questions.

Mr. Chairman, I join with you today in welcoming Mr. James Beggs to this hearing on the NASA authorization for fiscal year 1983. I commend you gentlemen for your efforts and contributions toward the future directions for our Nation's space program.

We meet here today in an atmosphere dominated by budgetary constraint, and like most of my colleagues in the Senate, I have supported cuts in Federal spending in order to return fiscal responsibility to the Government. But in carrying out congressional responsibility, we must not neglect to recognize the vital importance of the National Aeronautics and Space Administration's programs and their extremely beneficial applications toward the economic growth of this country.

The United States has been involved in space flight for over 20 years; the first U.S. space probe, Explorer I, was launched on January 31, 1958. Two decades later, this Nation had advance from launching Earth-orbiting satellites to placing men on the Moon. Even further, NASA is making giant leaps in deep space exploration through its Voyager I and Voyager II spacecraft. The world was able to share in the success of NASA's Voyager mission as it viewed the spectacular images of Jupiter and Saturn sent back by the Voyager I satellite.

During the mid-1970's, Skylab heralded the successful attempt toward unmanned application satellites. A single space station orbiting Earth was established to which three crews were sent and experiments were completed in this nongravitational atmosphere. Toward further development in this area of space industry, NASA created the cornerstone of the current U.S. manned space program—the Space Shuttle. The Shuttle will make access to space routine and relatively inexpensive, thereby increasing business in space for the future.

The United States has benefited immeasurably in every conceivable area from the technological and scientific achievements of NASA. For example, satellites used in communications, navigation, meteorology, and television create billions of dollars in businesses which employ thousands of people. And, according to space industry journals, these numbers are expected to grow over the next decade. Furthermore, advances have been made in medicine, such as more accurate diagnoses of breast cancer, due to development of an infrared scanner and television display developed for Marshall Space Flight Center.

And we cannot overlook the tremendous benefits of space technology to our national security. For example, under the auspices of the Department of Defense, satellites are used for reconnaissance in photographic, electronic, early warning, ocean surveillance, and nuclear explosion detection.

These programs which insure our national security and our natonal economic well being must be maintained. However, upon examination of NASA's 1982 operating plan and proposed budget for fiscal year 1983, I am dismayed over the direction our national space program appears to be taking. A number of important programs have either been eliminated or severely trimmed, and there is a decline in emphasis by NASA in the vital areas of applications, space science, aeronautics, and space exploration. The potential contributions of these programs and the result of their cutback must be carefully examined at today's hearing.

While other countries continue to mount impressive new research and development in aerospace programs, the United States is leveling off, putting more funds into fewer programs. If the United States is to continue its leadership role in space, we must be willing to devote the necessary resources to our national space program. It is my belief that the benefits our country has reaped from space applications can be even greater in the future if the United States continues its commitment to NASA space science and developments.

I look forward to the opportunity to examine the future of our national space program today.

Thank you, Mr. Chairman.

Mr. Beggs, I would like to ask about the space platform. You stated in the past that NASA's next major goal would be to develop the capability for long-term operation in space, either through manned or unmanned platforms. These platforms would be a Shuttle intended to be a permanent facility placed in low Earth orbit to provide support to many aggregated science applications and material processing experiments simultaneously. What is the status of NASA's studies in these areas, and when are they likely to come forward with a proposal?

Mr. **Beggs**. We are in the phase B study on the space platform, which means we are proceeding to the point where we are studying various and sundry concepts and options as to how we would construct such a platform, the sizing of it and the modes of operation and so forth. I think we will be prepared within about 6 months to outline the various options of what it will look like and to bring forward some kind of a proposal to proceed to the next stage.

Senator **Heflin**. All right, sir. Let me ask you about material processing. Material processing in space stands to be one of the greatest activities of national interest, potential at least equivalent to or greater than that of weather satellites and communications satellites. This important activity emphasizes the science and technology of processing materials under conditions that will allow for detailed examinations of the constraints imposed by gravitational forces. What research and development activities does NASA plan for materials processing in 1985 and later years?

Mr. **Beggs**. We have a number of activities underway, sir. We have two signed agreements with industry for activities looking toward industrialization in space. In total, we have about $24 million in the activity in fiscal year 1982. That activity is primarily connected with the basic studies of materials processing and integrating and carrying those kinds of payloads into space on the Shuttle as well as doing work to see how we service those facilities once they are in orbit. We are also looking to the day when they will become truly operational, that is, assuming there is a true commercial development of one or the other of these activities, and at how we would go about servicing, selling and maintaining that particular commercial activity.

I am satisfied that what we are doing will facilitate the entry into space of the private sector. I think what is really necessary in this field is for these early experiments to take place to demonstrate that there are viable profitmaking opportunities in space processing. Once somebody starts to make some money out of it, you can be sure that a lot of others will follow.

Senator **Heflin**. Let me ask you about lasar technology. That is the status of NASA's high-powered lasar program and what is the funding level for 1983?

Mr. **Beggs**. In the high-power area, Senator Heflin, we have only a small effort. Through 1976, we had a research and technology program in the low-power area potentially working up to a few hundred watts. That activity was primarily related to the communications technology but has been redirected to laser sensing and laser ranging.

Senator **Heflin**. What specific institutional contacts coordination or information-sharing meetings were held between NASA's high energy lasar scientists, engineers, and managers, and their counterparts in the Department of Defense, high-energy lasar program so far during fiscal year 1981?

Dr. **Olstad**. A formal coordination mechanism goes by the acronym HELRG, high-energy laser review group that meets on a regular basis. NASA and the Department of Energy have been participating in HELRG meetings for about a year.

Senator **Heflin**. What is a regular basis? How often?

Dr. **Olstad**. There is the group itself, which meets quarterly. There are some subgroups which do not meet on a regularly scheduled basis, but as needed.

Senator **Heflin**. During the past year, what has been—you take one subgroup, have they met more than once during the year?

Dr. **Olstad**. I would have to ask that question of someone else.

Senator **Schmitt**. It is obviously not a big item.

Mr. **Beggs**. It really isn't.

Senator **Heflin**. The Russians may make it one before long. They are pretty well 5 to 10 years ahead of the United States in this field, and it may well be that all of a sudden you will wake up and be faced with the situation where you will have to give some thought to it. It may well be after some tremendous national occurrence comes into being that causes this, where all of a sudden one day we woke up to Sputnik. I think it is something that some sort of consideration ought to be given to.

From my hearings that we had, we had four of them, there was no question that the Russians are spending a vast amount more money in laser technology and are far ahead of us in the development. I merely mention this as something that I think NASA as well as the other segments of Government have got to give some attention to.

I believe that's all.

Senator **Schmitt**. As you know, on the defense side of things, particularly in the Defense Appropriations Committee, we have been successful in continuing an increasing level of investment in laser technology in the Department of Defense. I concur with you, it is disappointing to see that NASA is not more deeply involved, at least in the consultative aspects of it.

Jim, do you expect to degrade the science at all, if you do end up having to use the IUS vehicle instead of the Centaur vehicle for Galileo?

Mr. **Beggs**. The arrival will, of course, Mr. Chairman, be about 2 years later than it would be via a direct trajectory because of the way we will have to fly. To that extent, the scientific information will be obtained later than originally planned. We will get fewer satellite encounter with the orbiter; therefore, there will be some small degradation of the amount of data that we can obtain with the orbiter. My understanding is that we will get most of the science that we had expected to get with the exception of the fact that we will get the data 2 years later. Andy, would you care to comment?

Mr. **Stofan**. The number of tours we would have gotten from the basic mission 11, we are not down to 6. We will get fewer satellite encounters with IUS launch. I would estimate 10- to 20-percent degradation in the science content of the mission.

Senator **Schmitt**. What do you estimate is the increased risk of loss of the satellite for the 2-year additional flight time? Do you have any statistical basis? You have not lost very many satellites.

Mr. **Stofan**. No.

Senator SCHMITT. Excuse me, very many spacecraft in interplanetary activity. That has been one of the highlights of the NASA program, as compared to that of the Soviet Union. But still, do you have estimates of risk?

Mr. STOFAN. No; we do not know. This launch mode will add another 30-month trip time to the mission, but we probably would have not designed the Galileo spacecraft any differently had we known earlier of the additional trip time than we are presently doing it.

Mr. BEGGS. My understanding of the discussions we have had at JPL is that they feel confident that the risk losing the spacecraft on the way is low. One has to assume that 2 years additional trip time adds some measure of risk. However, what percentage that would be I think is conjecture, but 2 more years of flight time adds some risk.

Senator SCHMITT. Does the trajectory, particularly through the asteroid belt, in any way increase or decrease the risk for that extra 2-year trajectory? Is there any difference in the flight back?

Mr. STOFAN. No; the flight trajectory takes the spacecraft out and keeps them about one AU from the sun, before they come back and loop by the Earth. Once they loop by the Earth, the trajectory to Jupiter is about the same as the direct trajectory. It is the added 30 months in the plane of the Earth is where we get the extra energy.

Senator SCHMITT. Jim, is it your feeling that the technology that has been put together and proved for basically remote operation of these deep-space craft has been fully transferred to defense applications near Earth?

Mr. BEGGS. I think most of it has, Mr. Chairman. I think they have been following most of what we have been doing.

Senator SCHMITT. Has there been any specific coordination of the examination of that deep-space technology for its application?

Mr. SMYLIE. There is currently a study underway at JPL, in conjunction with the DOD, regarding the applications of the automated spacecraft design to their lower orbit spacecraft.

Senator SCHMITT. That is underway?

Mr. SMYLIE. I believe so.

Senator SCHMITT. Can you provide the committee with an unclassified summary of that effort?

Mr. BEGGS. Yes, sir.

[The following information was subsequently received for the record:]

Some needs of the Air Force could lend themselves to the application of JPL autonomous systems experience gained from planetary flights. JPL has employed extensive economy on their NASA planetary spacecraft, especially over the past decade. This autonomy is needed because of the long two-way communication times, which make timely real-time anomaly analysis and correction impossible. It is also needed to assure reliable operation during the spacecraft's long transit time to planetary bodies and during the intensive data-gathering period.

JPL and the Air Force Space Division entered into a Memorandum of Understanding (MOU) on October 25, 1981. This MOU is intended to expedite the transfer of JPL-unique skills and technologies to the Space Division and their industrial contractors and to assist the Space Division in the integration of new technology into systems which can be incorporated into satellite systems. One specific effort of this type was initiated during the fall of 1980 well in advance of the formal MOU. This effort known as the "Autonomous Spacecraft Project."

Senator SCHMITT. Senator Heflin, do you have another round of questions?

Senator HEFLIN. Yes.

Senator SCHMITT. Proceed.

Senator HEFLIN. Let me go into planetary exploration, your operating planning in the 1983 budget proposal reflects NASA's apparent intention to defer further substantial activity for the development of a solar electrical propulsion system until a specific mission requirement is identified. This appears to go along with the change in emphasis by NASA with respect to planetary exploration.

What does this change mean to the Nation? And can you tell me if new planetary missions are under current study by NASA?

Mr. BEGGS. We still have a number of potential missions under study. Our intent is to try to outline a program which perhaps would involve lower cost missions, perhaps designed for a narrower range of information. For example, while we have terminated our activity on the VOIR, using a synthetic aperture radar, we are anticipating doing the mission in a different lower cost way. The JPL will be reviewing a number of different missions which previously were under consideration, with the objective of developing a plan which would bring forward planetary missions of lower cost, but yet significant scientific return. We have yet to come up with such a plan, but we expect to do that within the coming year or so.

With respect to the solar electric propulsion system [SEPS], we have not developed a specific requirement for that technology. However, it is our intent to use those funds with the committee's concurrence for looking at the advanced space-flight programs with respect to a platform. The technologies are essentially the same. As a matter of fact, the people who will be involved in that work will be essentially the same individuals and the work will be done at Marshall and to some extent using the Johnson activities.

But, we think that the kind of solar arrays that will have to be constructed and the kind of technology that will be involved in adapting them to platforms is essentially the same kind of technology we will ultimately need for the propulsion system. We feel that the requirements for such a system, with respect to planetary flight, are further out. Therefore, we would like to put a more near-term emphasis on the platform.

Senator HEFLIN. Senator Cannon had a couple of questions that I have been requested to ask.

Last year a group of private investors developed a rocket called Percheron for launch off the Texas coast. You were quoted as being encouraged by their initiative and welcomed the competition. What is NASA or others in the administration doing to protect the public safety and the international obligations, while at the same time encouraging entrepreneurial efforts such as the Percheron or other private space transportation initiatives?

Mr. BEGGS. I have personally had a couple of conversations with that organization. There are, as your question outlines, a number of safety and international implications resulting from private launches of this type. We have initiated a series of discussions to get the State Department to set up a procedure by which a private developer could get the necessary approvals. We have also discussed with FAA the approvals to fly a launch vehicle through the air space, and there are established procedures for doing that.

We are trying to get all of this outlined. Incidentally, there are the various private individuals and private companies that are interested in doing private development of launch vehicles can, in a straightforward way apply for the necessary approvals. Personally, I believe that that can be done, Senator Heflin.

I am encouraged by the response we have received from the State Department, the FAA, and the FCC where you will need approvals for communications.

Senator HEFLIN. What is the status of a proposal by a group of investors to purchase a fifth Shuttle orbiter with private funds but have NASA operate it?

Mr. BEGGS. A week or so ago, we have received a formal proposal from them. We are in the process of evaluating that proposal and it is a fairly complex financial arrangement. The proposal involves certain things that the investors would expect from the Government; and, at the same time, certain requirements that they would need in order to make this a viable financial proposal which they can take to the public or to their private investors. I really cannot answer your question as to what our position is on it.

To me, it is enormously encouraging that we are getting a lot of entrepreneurial activity in the space program. We have had the case of the people in Texas who are interested in launch vehicles. Another group came forward with a proposal to privately fund the fifth orbiter. We have had a couple of other preliminary discussions with various individuals to participate in putting private capital into a space station. All of this, I think, is encouraging in that it indicates that the entrepreneurs, at least, see some real commercial opportunities in this area. That should give us all a big boost.

Senator HEFLIN. Are you satisfied that the planning and management of the Shuttle operations are being conducted on a sound business basis?

Mr. BEGGS. I guess the short answer, Senator Heflin, is, "Yes." I am satisfied that we are on a sound business basis. The reason I am hesitant is that we are a long way from really understanding what our costs are going to be on the Shuttle and the Shuttle operations. We have an awful lot of work to do to put it on a basis where we really have a thorough understanding of what our costs are going to be, how quickly we are going to be able to come down the learning curves, and how well we are going to be able to meet the projections that were made a number of years ago on the cost base.

Until we get to that point—and we are really probably a few years away from reaching that point—we are not going to be on as sound a business basis as we should be. But, I think that is normal in a situation like this. We have come 10 years through a development effort. The pricing scheme was set on the basis of flat pricing over a mission model, without really knowing whether that mission model or the market was going to develop. As we get closer, we see the market developing. We also see a lot of problems in reaching a high flight rate. So, we have got a lot of hurdles to overcome; but, I am satisfied that where we are now we have a sound business arrangement with the various people who want to fly on the Shuttle.

We do have some additional homework to do to insure that the pricing beyond 1985 is adequate to cover the costs of our flights on the mission model that will then exist.

I do not think that I have really completely answered your question, but that is about as good as I can do right now.

Senator HEFLIN. For example, do you think that the Shuttle is competitive with the French Ariane rocket, both in terms of launch cost and financial arrangements?

Mr. BEGGS. Yes, sir. It is competitive on the basis of launch cost. You have to remember that the Ariane is an Atlas-class rocket. In that, they are right at the beginning of the learning curve. They have just completed its development. It is very hard to find out what it is costing the European partners to produce that system and to transport it to South America and launch it. But, it has got to be very expensive.

In my judgment, we are very much in the competitive ball park with regard to the cost per launch. Once the Shuttle system is operational, we will have much greater capability in the Shuttle than they do with an expendable launch vehicle. We will be more than competitive in the other features, such as being able to revisit, repair on orbit, bring payloads back, and so forth.

With regard to the second part of your question, that is a horse of a different color. The French are pricing their service very, very competitively. As a matter of fact, they have set the price very close to Shuttle-type pricing. They are, without any question, subsidizing that, because their costs are not down. With respect to the cost per launch and the financial terms—the payment terms and the terms on which they sell, which allow cancellation of the position on very easy terms—they are more than competitive with us. They have already sold a couple of payloads in this country. How many to the rest of the world, I don't know. But they have come into our market and sold two payloads, and they are actively negotiating with a number of others. So, they are formidable competition, and we are not taking them lightly.

Senator HEFLIN. Do you think that the current Shuttle launch schedule is adequate to meet the demands through 1985 and beyond?

Mr. BEGGS. With the backup we have with the Delta class expendables, the model we have constructed through fiscal year 1985 is adequate to meet the demand. We would like to fly more, Senator Heflin. The charge I have laid on our people is to push as hard as we can to get our system in order so that if the demand develops even further in the out years, we will be capable of flying at higher rates. But, we think we have constructed the ramp up to that 24-per-year flight rate, which, incidentally, is a stop toward an even higher rate. In looking at where we stood with respect to the expendables, external tanks, and SRB's, we feel that that ramp is about as good as we can project at the present time.

We hope to fly three times this year. If we can increase that to four, we will. We will be trying to fly ramp up from that 3 to 5, to 10, to 13, to 18, and to the 24. If you look at where we are right now, that is a fairly ambitious schedule. But we think that, with some hard work and by working the bottleneck problems, perhaps we can get there faster. We will be trying to do that.

Senator SCHMITT. Jim, did you request funding for the fifth orbiter from OMB?

Mr. BEGGS. Yes, I did.

Senator SCHMITT. At what level?

Mr. BEGGS. $1.3 billion—in the fiscal year 1983 budget?

Senator SCHMITT. Yes.

Mr. BEGGS. $90 million.

Senator SCHMITT. $90 million with, I take it, an estimated runout cost of $1.3 billion?

Mr. BEGGS. Yes, sir.

Senator SCHMITT. What is the delivery date that that represents?

Mr. BEGGS. I believe it is 1986 or early 1987.

Senator SCHMITT. Senator Heflin got into the current demand for flights to some degree. At the current schedule, aren't you booked up?

Mr. BEGGS. We are booked.

Senator SCHMITT. How far into the future?

Mr. BEGGS. We are booked; but a couple of those bookings are contingent bookings which are bookings based on having to replace some satellites in orbit. If those satellites do not require replacement, then we would have an opening in the schedule. However, we are fully booked through fiscal year 1985 and we are starting to look into requests for bookings in fiscal year 1986. As a matter of fact, we have a couple of bookings in fiscal year 1986, so that the market is there. I did not mean to imply in my answer to Senator Heflin that the market was not there.

What I am saying is that we think we have an ambitious schedule to get up through the 24-per-year flight rate in the number of years we are projecting, and we are going to try to beat that. But right now, we have got problems in producing the expendables that we have got to overcome. We have not yet produced the first lightweight external tank. So, we do not know yet just exactly where we stand. When we do take a hard look at it, we will see if we can take on some more customers, assuming the market is there. If the market develops even further, we will expand our flight rate to the 30-per-year rate that we previously projected.

Senator SCHMITT. With four or five orbiters?

Mr. BEGGS. We would like to have the five. You can reach a 30-per-year rate with four. But, in my judgment, to fly that many flights with just four orbiters is getting close to the margin, because it is probable that we are going to want to have one orbiter down at any given point in time for modifications or improvements on it as we learn through flight. It is also possible, although I hope and pray that it will never happen, that we might have an accident on landing, for example, where an orbiter would be out of service for repairs. So, I think, four is marginal for flying up to that 30 per year; we would like to have the fifth. Therefore, we will be pushing to get the fifth.

Senator SCHMITT. Without the fifth, is there an increased risk that the Ariane will take a major portion of the future Shuttle market?

Mr. BEGGS. Ariane is going to get a share of this market no matter what we do, because they are going to price their service to get a piece of the market. In short, they are going to buy their way in, just as they have done in the case of the airbus. They have bought themselves into the transport market on a subsidized price. I fully expect, no matter what we do on pricing or what we do on service, that they are going to price and promise to be competitive to get a share of the market.

We are going to try to operate our system as efficiently and price it as we are the price leader in this field to hold our market position. I believe we can do that. I think the other advantages that the Shuttle gives other than just simply putting a payload into orbit, are sufficient to hold a dominant or preeminent market position. But, we are going to have to look to our laurels, they are coming fast, they are working hard.

Senator SCHMITT. What is the current position of the insurance industry comparing Ariane with Shuttle?

Mr. BEGGS. I really do not know the answer to your question specifically. I do know that the insurance industry, with respect to the expendables we fly, are generally willing to provide coverage at competitive rates.

Senator SCHMITT. Prior to the first successful flight of the Ariane after the engine problem—I presume it was an engine problem—I had heard that it was not possible to get insurance for an Ariane flight. Is that changed?

Mr. BEGGS. I believe that they now have several of the underwriters willing to cover. I think it is at a somewhat higher rate than Shuttle, but still competitive.

Senator SCHMITT. Could you give the subcommittee some information for the record?

[The following information was subsequently received for the record:]

We have spoken with a number of underwriters in the past 3 months and have determined as a consensus the following:

1. Insurance rates for Ariane today are 2-3 percentage points higher than for NASA's Delta expendable launch vehicle; however, an average of seven Ariane successes is seen as sufficient to bring the Ariane premium equivalent to Delta at about 10 percent.
2. For the first two Shuttle missions, the aggregate insurance premium for COMSAT launched off Delta and off Shuttle are approximately the same. With successful deployments from Shuttle demonstrated, it is anticipated that the Shuttle premium could be 1-2 percentage points below Delta ELV and Ariane.
3. A problem unique to Shuttle will be the need to aggregate coverage sources because of up to four payloads carried (as opposed to Delta). This is in some measure true for Ariane which will carry two payloads at one time.
4. Demonstrations for both Shuttle and Ariane are keys to establishment of premiums. For the Shuttle, if fully successful, it will provide an implicit cost benefit, vs. Ariane, for launching COMSATS.

Dr. WEISS. They are able to get the current underwriters to provide insurance for Ariane. There is about a 1-percent premium over the rates that are charged for Delta and Shuttle at this time. That is a very marked change since the last two successful launches for Ariane.

Senator SCHMITT. What is the impact, as you see it, on national security needs of a four-fleet Shuttle fleet versus a five-fleet Shuttle?

Mr. BEGGS. As I think has been stated a number of times before to the subcommittee, the national defense payloads are the highest priority which means we must always have a Shuttle available to them for their mission. In essence, this means that we have got to have a Shuttle working the defense missions and that we probably have to provide a backup or at least a contingent backup Shuttle, for them. This means that we have got half of the fleet committed to one-third of the market. Again, it makes the fifth orbiter highly desirable.

Senator SCHMITT. Are you getting any hints that the Department of Defense might be willing to help you finance it?

Mr. BEGGS. No; their position, I think, has been consistent on this.

Senator SCHMITT. That's for sure.

Mr. BEGGS. It has the virtue of consistency. Their position has been that they are investing substantial funds in Vandenberg, and that they have an additional large investment to make in their operations center. With that investment, they are putting a very large commitment to Shuttle, and that is as far as they should go.

Senator SCHMITT. I am glad they do not follow that policy in the development of an Air Force, that is, build all the runways and the operational facilities and let somebody else build the airplanes.

Mr. BEGGS. The Shuttle, after all, was a national commitment that was undertaken on the basis that NASA would develop it for all of the users. I think that position has remained constant through the years.

Senator SCHMITT. But it was undertaken with the understanding that the other purposes of the Space Act were going to be fully fulfilled, and it is not clear that they are being fulfilled right now under the present changed budget situation, the changed economic situation. And I do not see any reason why the Air Force should be able to hide behind that earlier decision when NASA is not being able to hide behind it. You are cutting the rest of your budget in order to provide this national capability.

I fully recognize that the investment the Air Force is making is in Vandenberg and possibly in space operation centers in the investments in Houston, but I also recognize that those are meaningless investments unless there is an available fleet of Shuttles. I also recognize that the Air Force has no idea right now how they are going to use this Space Shuttle, other than to do what they are already doing, utilizing that launch vehicle. As far as thinking in terms of future activities, those that do more than just support their current mission, they have not begun that process and they have no identifiable internal mechanism by which they can undertake that process.

Mr. BEGGS. The reductions that have been made in the NASA budget were made in the last 7 or 8 years. It is true that if we had a constant budget, that is constant in terms of the escalation that has proceeded in the last 10 years, the amount of money that we would have with relation to the fiscal year 1973 budget which I think was $3.4 billion, would be $8 billion. So, we are off by about $1.5 billion. This administration has given us an increase this year which is worthy of note.

Senator SCHMITT. We take note of that.

Mr. BEGGS. They could not get us back up to what we have lost over the last several years, but we did get an increase and that is a commitment. I believe that they support the program and they intend to maintain a thrust into the future years. I hope that with respect to things like Orbiter 105 and some of the other programs that we can look forward to maybe a little more sympathetic climate in the future.

Senator SCHMITT. Are you working with Ambassador Brock and others on trying to modify administratively or request legislation to modify the possible range of financing arrangements that you and U.S. industry can offer to foreign purchasers of launch services and satellites?

Mr. BEGGS. Yes, sir. We have had a number of discussions. I have also discussed this with Bill Draper at Ex-Im to see what we can do. Ex-Im, for example, has been very forthcoming in trying to sustain the competitive position of the United States in the commercial satellite market. Ex-Im has agreed to look into financing of our launch services, including Shuttle, to give us some help in a couple of cases, haven't they, Stan?

Dr. WEISS. They have committed to Columbia, and are looking now at the Brazilian and Mexican communication satellite systems and launches.

Mr. BEGGS. So, we have some support there. We have also sent a couple of letters to Ambassador Brock and to the State Department highlighting the fact that the Ariane is conducting this campaign. We believe it is being conducted and priced at below-cost levels, therefore, we are suggesting that perhaps this issue should be raised with them.

I know that Ambassador Brock is very interested in this issue. We have discussed it with his staff a couple of times to give them additional facts on it; so, we are working the problem. But as I said earlier, my feeling on this is that we are confronted with a very formidable competitor who is going to buy his way into the market.

Senator SCHMITT. It is my understanding, with a very preliminary look at this and preliminary discussions with both industry and Ambassador Brock, that there are legal limits that prevent us from going as far as the French have gone. For example, I guess we are pretty well out of the running in the Australian satellite competition, are we not? Does somebody have an update on that? I understand that the French are potentially underbidding by about $40 million.

Mr. BEGGS. That's right. They have put a very, very attractive deal on the table. I do not think we are totally out of the running as yet. I think the Australians still would like to buy an American satellite, but obviously they have got problems in rationalizing a difference of that type.

The other thing that I am sure we're going to run into in a competitive sense is that both the French company which provides launch services and the French company which builds satellites are government owned. They are, therefore, capable of offering package deals where they offer both the satellite and the launch services as a package and price it accordingly. I think that will be a ploy that we can envision their employing some time in the future.

Senator SCHMITT. What is the justification for NASA's inclusion of the filament wound case in the fiscal year 1982 operating plan, since it was not in the 1982 budget request?

Mr. **Beggs**. In looking at where we stand on the filament wound case, we found that both the two primary competitors were ready to go into a competition. The only thing that had to be resolved was the way in which we would hold that competition. With the projected development schedules, we felt that it would be advisable to start in fiscal year 1982 rather than waiting until fiscal year 1983; and, therefore, we are requesting that reprograming.

It is a very significant development program. The weight saving that we can get by virtue of using the filament wound case is a fairly sizable increment in what we need to lift some of the heavier payloads in the outyears. So, we want to get started this year. We have currently initiated the preliminary discussions with the contractors to outline the terms of the RFP, and we are hopeful the committees will go along with us on that.

Senator **Schmitt**. What is NASA's requirement for that, other than to provide a higher payload offering, weight payload offering to the users?

Mr. **Beggs**. As I have reviewed it, there will be an improvement in terms of the recoverability and reusability of the SRB which translates into dollars in the outyears. In addition, I think that as we look into the future of fiscal year 1985 and beyond, the Comsat and other users, who are looking at advanced systems in the late 1980's, are looking at fairly heavy platforms. From a commercial point of view, we would like to have that additional lift.

Senator **Schmitt**. Right now the only identified payloads are DOD payloads?

Mr. **Beggs**. That's correct. But, we are looking at commercial payloads that are heavyweights.

Senator **Schmitt**. At least at the present time the acceleration of this benefits principally the Department of Defense.

Mr. **Beggs**. The lightweight case makes the system, I think, both more reliable and longer lived. The lighter weight case, of course, allows us to extend engine life because we should be able to lower the thrust level of the main engines to some extent.

Senator **Schmitt**. I am very supportive and always have been, of thrust augmentation. I think it is a natural evolution of any booster system that we have ever had. It is one that you ought to continue, but I think that the primary beneficiary should contribute to its cost and to seeing that it comes on line in a hurry. There is no reason why all potential users should not contribute to the cost of this case. I presume that future users from the commercial sector will pay a price for having developed it, in order to have an increased capability, payload capability, I would hope that the Department of Defense would again, as I have indicated with respect to high energy upper stage and the fifth orbiter, begin to evaluate their participation in this program.

Was there ever any discussion with the Department of Defense that there might be a joint funding of this lightweight case?

Mr. **Beggs**. Not with respect to the filament wound case. We have had some very preliminary discussions with respect to RL-10, but we have not discussed funding for neither the lightweight case or the main engine.

Senator **Schmitt**. Jim, as you know, I am tremendously disturbed by the loss of basic technology, research and technology development capability, as a result of the cutback in various reimbursable funds that have gone to NASA for energy programs, particularly, those programs that are designed to increase efficiency of various forms of energy. What has been the impact on NASA from where we were a year ago of these reductions, in terms of manpower and programs?

Mr. BEGGS. The manpower is down at several of the centers. We are moving out of this field, because of reductions in the budget for this fiscal year. We will be down by 250 positions by 1983 assuming that the budget proposals for the Department of Energy are put into effect in the NASA centers. We will virtually go out of the business by the end of fiscal year 1983. Right now that amounts to about 250 positions. Most of that work or a large part of that work is done through contract; so, it has never been a very large manpower consumer even though the program has been of significant size. It was well over $100 million this past year. It has been, as you say, a very interesting program for the agency, and I think very useful work was done.

I should amend my statement that we will be out of the energy business. All of the NASA centers will be out, but JPL will remain in the field in carrying on some of the solar panel work that has been pursued. I think that work will go forward.

Senator SCHMITT. So the work on high-efficiency external combustion engines, battery systems, other end-use efficiency efforts that were undertaken beginning in 1974 by the agency on a reimbursable basis, are esentially terminated with this budget.

Mr. BEGGS. DOE has informed me that we should plan for it essentially to wind down to nothing by the end of fiscal year 1983.

Senator SCHMITT. Do you view this situation with glee or with regret or ambivalence? Do you think this is another example of where the private sector should pick up these activities?

Mr. BEGGS. I am ambivalent on that point. There has been a lot of good work done. Some of the work would not otherwise have been done and probably will not be picked up. We probably got extended a little bit too far into areas where industry should and would provide the R. & D. backup, but I think most of the work that NASA did at Lewis probably was very good. I am told by the electric utility people that the wind turbine work, for example, would not have been done by the industry without the NASA program. That work simply would not have moved to the point where it is. However, with respect to that particular piece of technology that is now being applied, I think it will be carried to the point of practical application. Some commercial installations are working on it now, and they project more will take place.

The work on Stirling engine and that class of engine work probably will cease. I do not see industry picking that up. Clearly, the application of space-type technology, solar, electric, what have you, that probably——

Senator SCHMITT. So we are back to where we were in early 1974. As far as end-use efficiency of energy, the technology developed in space and the expertise that resides within both Government and industry, will be transferred only by accident, rather than by design, into the private sector.

Mr. BEGGS. I think I would be a little less direct on that. I think the work that has been done will be transferred. Because a lot of it was done by the industry, I think they have benefited. However, the question that I cannot come to grips with is: "How much money and how much additional effort they will put into that?" I think it depends on the area. I think, they will continue or pursue some areas. Others they will drop. Obviously, the things that are farthest away because of the time horizon most industry has with respect to their investments, are the things that probably will be lost.

When you are looking at discount rates of 15 percent or more or anything that goes out beyond 8 or 10 years in a commercial sense, it is very hard to figure you are going to be able to make a profitable commercial venture out of it. So those things that are out 7, 8, 9, 10 years, I think, will be lost. But there are some things that are closer in that I think will be continued. Some of the battery work possibly will be, as well as some of the wind turbine work. Maybe there are some other areas that do not come to mind.

Senator SCHMITT. Continued by the DOD?

Mr. BEGGS. Continued by the industry.

Senator SCHMITT. By the industry.

Well, I think we are making a serious mistake, and I have made my views known to the Secretary of Commerce and his people that in end-use efficiency, our biggest problem is the same one that has faced the airline industry for a long time, and that is the extension of known techniques to an economic—to a technically and economically feasible level, so that they can be applied within the total economy. Obviously, the major expenditures in conservation by the Department of Energy since its formation have been in large part wasted. The demonstration of large-scale solar powerplants was something that we recommended against, NASA in those days recommended against in 1974 and 1975, that the real need for solar energy and most of these other technologies was research and technology at the component level, so that they could become economical on a gradual scale, and as result of lower cost of production and ease of maintainability and increase in reliability. That is basically the kind of program NASA had been asked to undertake, and that is what is being dropped along with everything else, apparently, in the conservation area.

I hope that under the new organization plan, if it is approved by the Congress, we will see finally a recognition of the value of that kind of an effort. Whether it is done in NASA or not is another decision to make, but clearly both NASA and its industries' technologies are directly applicable in many cases to this increase in use efficiency.

The absence in the marketplace now of an air breathing fuel cell is something that, in my opinion, has nothing to do with a majority of the technology. It has to do purely with the ability of the industry to capitalize the initial investments. That was true in 1974 and it is true today. And that is not an insignificant system. That represents a potential 10 to 15 percentage point increase over the efficiency of the existing central station power production.

Now overall in manpower, Jim, there are going to be significant manpower reductions for this fiscal year, as well as 1983 within

NASA. You have had a declining work force for many years. What is this doing to your ability to rejuvenate the technical manpower reservoir of the agency?

Mr. BEGGS. The reductions that we are looking at from fiscal year 1982 to fiscal year 1983 are fairly modest in size. We are coming down about 221 in 1982 and another 433 in fiscal year 1983. This will bring us down to about 21,000 in total, which is, we have been told something we can plan on out into the out years. So putting some stability in the manpower in the Agency, I think, is a very good outcome of the fiscal year 1983 budget cycle. The one area that bothers me quite a bit is in hiring the young college graduates each year. We have not been hiring enough of them as we have been coming down in numbers over the years. Therefore, the Agency is getting older as a consequence of that, which is always a disturbing trend. We have been getting almost half a year older on the average every year in the past few years in our scientific and engineering work force. We are going to work very hard to try to use our attrition to hire young college graduates to lower the average age again.

We are behind this year, although we have asked the center directors to continue the recruiting to wedge the graduates into their work force. We will be doing the same thing next year, but it is made more difficult by that reduction. This is the argument we have been making for the past several months, that we need those young people; that is the future of the agency and the future of the Nation. It is a disturbing trend. We have a plan to hire in spite of these reductions, and we will be proceeding with that.

The other part of it that worries me is that our entry level salaries are not really competitive with the industry. We were about 10 percent below the industry this past recruiting year. With the normal increases in the surveys we have, it seems to indicate that we will fall behind maybe another 5 to 10 percent this year in entry level salaries. We are still able to attract some very good students, because we have interesting work for them to do. A lot of the young graduates will go after that work, and that, I think, we will be playing that up even more. But, it is disturbing that the entry level salaries are continuing to fall behind the competitive levels being offered by industrial recruiters.

I received a letter just yesterday from one of the industrial relations people who had been recruiting down at University of Texas or Texas A & M. He said one of the students had said to him that he was very much interested in NASA and that he would really like to go there. That the NASA co-op program was a very good program on which to work and that the work was very interesting. But, he said, their salaries are not nearly as good as he could get by offering his services to industry. This is the first time I had heard that comment coming from one of the students themselves. So it is worrisome.

Senator SCHMITT. Can you change that?

Mr. BEGGS. We have some flexibility, but it is very limited. Within that flexibility, the highest salary we can offer to a bachelor degree fresh out is still not competitive with what he can get in private industry. Based on June 1982 projections, we are falling further behind.

Senator SCHMITT. Looking at your launch schedule, what about your ability in both ground and site personnel to support that schedule? Do you see any problems there?

Mr. BEGGS. I do not see any problems right now. I think that we have a lot of work to do though in the area of payload integration and the handling of even 10 flights a year with respect to the various analyses that we will have to do. We have got to see how that is going to work itself out.

My objective is to try to get through those high-flight rates not by hiring more people but by learning. We are way down the experience curve, and we make manpower available by making the job more efficient all the time. I think we can do that. I'm not worried right now.

Senator SCHMITT. Do you expect to have a new on-flight selection? I hope they pass on my concern——

Mr. BEGGS. I don't know whether we are going to have one this year; but, I think, we will be entering one next year. We will try to make it an annual affair thereafter.

Senator SCHMITT. I have heard that before.

Mr. BEGGS. I know you have, and I know that there has been difficulty in the agency responding, but I have laid it on very hard.

Senator SCHMITT. You just haven't responded. You selected 35 astronauts out of the box for the new selection; you could have easily gone into an annual selection process at that time.

Mr. BEGGS. That is what we are planning to do, to go to an annual and select fewer.

Senator SCHMITT. There are a lot of young people out there who would like to know that in their future there is going to be a reasonably good chance to apply. They recognize the competition is stiff, but they still want to do it.

Mr. BEGGS. Sure. And, I want to keep their attention. The agency wants to keep their attention. It pays us to do that, and we will be working at that.

Senator SCHMITT. It sure does. What is NASA's relation to the Air Force planning on the Consolidated Space Operation Center? Are you involved in that in any direct way, or are they doing that on their own?

Mr. BEGGS. They are doing it mostly on their own, although we do have a consultative role. They have been taking advantage of our expertise and they have used it from time to time although we are not in their planning in any great detail.

Senator SCHMITT. The modifications of the Mission Control Center to handle Air Force payloads, are they essentially complete at this time?

Mr. BEGGS. I don't believe so.

General ABRAHAMSON. Sir, the first one to be completed is the one at Cape Kennedy. That is funded by the Air Force at $34 million. Unfortunately, I do not have the dollar amount here for the control center at Houston. If I may, I will provide that to you.

[The following information was subsequently received for the record:]

The facilities at JSC being modified are the Shuttle Mission Simulator (SMS), the Mission Control Center and the computing support in buildings 12 and 30. Modifications are now underway and we are planning to have DOD certify these facilities in

April 1983 with the ability to support Air Force payloads in July 1983. The current flight manifest has the first DOD payload to use the "control mode" capability at JSC scheduled for STS-10 in November/December 1983. The total nonrecovery real year cost for the "control mode" modifications at JSC is $61 million through FY 1985 and is being funded by DOD.

Senator SCHMITT. Yes; we will have a chance to talk about it Thursday. Are you satisfied that the capability is going to be adequate to handle the payloads, DOD payloads, in the foreseeable future?

Mr. BEGGS. I am. I think we are prepared to support them.

Senator SCHMITT. I understand that you are still giving a high priority to the Solar Maximum Mission. Would you elaborate on why, for our record now, on why that mission is so important?

Mr. BEGGS. We think it demonstrates early a key capability of the Shuttle. It gives us the opportunity to do something useful and demonstrate that we can, indeed, repair on orbit, revisit an existing satellite and fix it.

As you know, the Solar Maximum Mission satellite is sick. We think we can get another couple of years out of that system if we fix it. According to the way we look at the priorities, it is somewhere fairly high on the priority list. In addition to that, of course, it demonstrates our ability to run that kind of mission. We are undoubtedly going to want to revisit to work on the Space Telescope as time goes on. Without any question, that capability is something that needs to be demonstrated early to give our customer community the warm feeling that they are sure we can do that.

Senator SCHMITT. They don't believe you right now?

Mr. BEGGS. I think they believe us. I think that they will need a good deal more confidence and will, therefore, tend to define their systems for that kind of activity in the future if we do demonstrate it. Obviously, it is also of value to the DOD, because they have satellites which will require repair. Therefore, I think it is important to demonstrate early that we can do it and it is not an enormous sum of money. It fits our program very well.

Senator SCHMITT. It looks enormous when you see some of the things that we aren't going to do. That is why I think the subcommittee is asking questions about it.

Mr. BEGGS. Sure.

Senator SCHMITT. What are your current production predictions for the Delta launch vehicle with the Centaur?

Mr. BEGGS. Let me ask Stan Weiss to respond to that.

Dr. WEISS. The production of the Delta has been tailored to about six per year now, consistent with our planned usage for communication satellites and a few NASA launches that we have in our meteorological systems. We will be flying the last of the Intelsat launches in 1984, and the Navy has recently ordered three more Atlas Centaurs for the FLEETSATCOM which will carry those launches out into 1986 or 1987. Frankly, I think we ought to discourage them from that because it involves bearing the whole cost of maintaining the system, including the vehicle and the launch facilities with just one launch per year.

Our final scheduled usage of the Delta right now is the end of 1986. We have in our current budget made provisions for long-lead items that would provide us flexibility for any additional usage.

Our usage is very much as a backup to the deficiency in availability of orbiters until 1986. So, we still have some customers coming aboard the expendable vehicles.

More importantly, it has given us the capability of offering a mix of Delta and Shuttle spots to users like the Columbia and Brazil to meet their launch dates with that sort of an accommodation.

Senator SCHMITT. Jim, how do you view cooperative space ventures these days? Do you see that improving or recovering after the unfortunate cancellations of recent years? Where are we on cooperative ventures?

Mr. BEGGS. I think it is a mixed picture. From my discussions with the various foreign space officials, they are still very much interested in future cooperative endeavors. If we were to propose cooperation in some programs in the future, they would look upon it favorably. At the same time, they have, in effect, told me that they will be looking for greater assurance from NASA in the future, that what they enter into is likely to proceed to a complete program. And I think that that is normal, considering past history in this field.

As you look around the world, the budgets are increasing, and I think that is an encouraging sign that they will be actively looking for opportunities. The French budget goes up significantly; the Japanese budget has been increasing over the last 5 years at a steady rate. The budgets of Germany and Canada have been up in the last several years. All of those aspects suggest that we can reach some very good cooperative programs.

I think they would be interested in something like the space platform, assuming that goes forward. They are always interested in science-type satellites, and I think they will be looking for opportunities there. The Europeans have been very pleased with the outcome of the cooperation involved in Spacelab. They were pleased with the cooperative spirit, exchange of technology that occurred during that program, and at the delivery of the Spacelab to the Kennedy Space Center a few weeks ago. They were all very complimentary about that program. One of them said to me, "Well, what is done is done; let's put it now behind us," speaking of the ISPM, "and go on to further cooperation." That was a happy occasion. But still and all, I think they are ready to enter into cooperation, and so are we.

I have been exploring the possibilities of future cooperation with both the Europeans and the Japanese as well as anyone else who wants to enter into our program.

Senator SCHMITT. Are you really going to lock up my lunar samples for a year?

Mr. BEGGS. We are looking at it, but I don't think so. We are looking at essentially mothballing that facility, but I do not think we are going to do that.

Senator SCHMITT. I would hope not. There is still a strong feeling out there, Jim, that NASA should be in the business of advanced communications R. & D. We got out of it for many years due to popular demand, as well as good, rational logic. We got back in. Now there seems to be a tendency to move away from that area again. What are your personal views with regard to NASA's role in high risk communications research and development?

Mr. **Beggs**. I think we ought to be doing the essential research and technology in the communications area. Of course, the main area we are reviewing now is the 30/20 gigahertz range which was opened up a few years back. There is a significant amount of activity going on in the area by our foreign competitors. Operating on the philosophic basis of not moving into hardware, we did terminate the activity that we had ongoing to fly that hardware, but we did not terminate the technology. We will be continuing that activity and will continue to work with industry to allow them access to it.

Senator **Schmitt**. Is there any danger that in abandoning the 30/20 gigahertz activity, we have essentially turned that area of technology over to our foreign competitors?

Mr. **Beggs**. We do have the problem in that the Japanese and the Europeans are moving ahead, the Japanese faster perhaps than anyone else, and we are reviewing this very carefully. The Japanese are moving ahead to the development of hardware, and as we, I think, have pointed out in the past, they are a year or so ahead of us.

Senator **Schmitt**. It is already too late?

Mr. **Beggs**. It may be too late, although I believe we can overcome any lead that they have now. But, we have to look at that area very carefully to see where they are going.

Senator **Schmitt**. They are going to get the market. I can tell you where they are going.

Mr. **Beggs**. Satellite communications has been an area where we have dominated. We almost had a monopoly in the world, and we should not give it away.

Senator **Schmitt**. Well, we are giving it away. All of the trends are against us, are they not?

Mr. **Beggs**. Right now, I believe that the development activities going on abroad, are more significant than what is going on in this country.

Senator **Schmitt**. Finally, Jim, what is the extent of your involvement in Unispace 1982?

Mr. **Beggs**. We have begun the preliminary planning after a decision by the administration to participate in Unispace 1982 in January. I have been designated to head up that planning, and we have started to put together the various task groups for the writing of position papers and the development of our plans. We have also started to get out communications to the industry that we are going to be present at Unispace so that they can take whatever action they desire to be represented themselves.

Senator **Schmitt**. Are you going to be the official head of the delegation?

Mr. **Beggs**. I believe so. Yes, sir.

Senator **Schmitt**. That is not official?

Mr. **Beggs**. It is not official yet.

Senator **Schmitt**. You do not have much time to get prepared, Jim.

Mr. **Beggs**. It is very short; but, we have begun our planning and are working on the papers to outline the U.S. position. We are coming in very late since the U.N. staff paper has already been written and published. We are coming from a position of having to take something that already exists, and where we disagree with it, we will have to work very hard to get our position in place.

Senator Schmitt. Are you going to be able, under present law, to draw on the expertise on the industry to assist you in this?

Mr. Beggs. Yes, sir, I believe so.

Senator Schmitt. I hope you will let us know if you see any problems in that.

Mr. Beggs. I will, indeed. I think we will have a pretty good preliminary look at where we stand by the end of this month. We will have talked to some of the industry leaders as well as have had an opportunity to solicit and canvas the other agencies of the Government.

Senator Schmitt. Well, do not expect to see very much perspective and understanding coming out of the State Department. The State Department's realization of just what these international communications and space conferences mean to the future of our own activities is very close to zero, in my experience, and it has remained so through several administrations. They still do not recognize the essential political nature of such conferences or the implications of decisions that may be made both for our future cooperation as well as for the directions that our technologies may have to take if the decisions are adverse to U.S. interests.

I hope that you and your staff, as well as others who get involved in it, will look to the history of U.S. involvement in past conferences, particularly 1979 and the upcoming conference, I guess, on region 2 work activities and what recently happened down in Rio de Janeiro. It is—we stumbled through and we survived, but just barely—in many cases we have sown some seeds that are going to be very difficult—weeds that are going to be very difficult to extract in the future.

Mr. Beggs. I agree. We are very far behind. There is a good institutional memory on this in the agency.

Senator Schmitt. I know. The technical side is always very good, and that is really what has carried us and kept us from being totally overwhelmed in these conferences, because we do our technical preparation very well. But the political preparation is abysmal, and I hope that you get better cooperation from the State Department than we have seen in recent years in other conferences.

Mr. Beggs. We will be trying to do that.

Senator Schmitt. Thank you, Jim. We will have a chance to talk more about some of these issues on Thursday, and we appreciate it very much. I know I have kept you quite a while, but it is an important year for the agency and we wish you well.

Mr. Beggs. I appreciate the opportunity to appear before you.

[The statement follows:]

Statement of

James M. Beggs
Administrator

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Science, Technology and Space
Committee on Commerce, Science and Transportation
United States Senate

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to appear today to present President Reagan's budget request for NASA for FY 1983. The total request is $6.613 billion of which $5.334 billion is for Research and Development, $100 million is for Construction of Facilities, and $1.179 billion is for Research and Program Management. A chart summarizing the request is appended to this statement.

During his first year in office, the President has clearly stated the two major policy priorities of the Administration. The first is to revive our economy and the second is to strengthen our national security. The control of inflation has been identified as this Administration's primary economic objective. Since inflation is related to spending by the Government, the total request, as submitted, reflects significant steps to reduce spending in FY 1983. At the same time, the military and political threat posed by the Soviet Union has increased steadily during the past two decades. Improving the Nation's defense posture is clearly the second major priority of the Administration. The FY 1983 budget request for the National Aeronautics and Space Administration has been prepared to be consistent with these broad and overriding priorities.

Before turning to the details of the request, I would like to review the significant contributions and challenges which I foresee for the Agency in the coming fiscal year.

The United States has conducted a vigorous space program for almost a quarter century under the broad policy guidelines set by the Congress in the National Aeronautics and Space Act of 1958. This far sighted piece of legislation has made it possible to conduct a program in both the public and private sectors that has led to truly remarkable scientific and technical achievements and to ever-increasing investments in terms of real dollars in aviation and space operations.

The large commercial communications satellites now in geostationary orbit are the direct technical descendents of NASA's early Applications Technology Satellites. The relative stability of the world today is dependent to a considerable extent on national security related satellites employing technology that was pioneered by NASA in the 1950's and 1960's. The success of this technology transfer to the commercial and military sectors is demonstrated by the fact that NASA today accounts for a smaller fraction of the national spending on space-related activities than in the past even though the NASA budget has remained relatively constant in real year dollars for the past few years. The national security related space program and the commercial programs have both seen very substantial increases in the past five years. These increases are related to important national security requirements as well as new commercial opportunities. The ability to satisfy these requirements and to exploit these opportunities is due in large measure to the work performed by NASA over the years.

In accord with the Administration's policies, NASA's FY 1983 program shows the retention of, or increases in, those programs that can be related directly to national security. We have also maintained a strong program in those fields directly related to the responsibilities of NASA under the National Aeronautics and Space Act. However, some programs have been reduced or delayed because of the urgent need to reduce Federal spending. We have heard expressions of concern that this balance of priorities can lead to the "militarization" of the Agency. I would like to assure you, Mr. Chairman, that this Administration is strongly committed to the maintenance of an independent NASA charged with pioneering new enterprises and technologies that will enhance the ability of the United States to conduct operations in space and aeronautics that further the objectives laid out in the National Aeronautics and Space Act and maintain the competitive posture of this country in aeronautics and space technology.

We are conducting our support of agencies with responsibilities in the area of national security under the provision of the Act that requires NASA to make "available to agencies directly concerned with national defense of discoveries that have military value or significance....."(Section 102(c)(6)). The case of aeronautics is a particularly important example. The President, in submitting his strategic force modernization program to the Congress in October 1981, has made commitments in excess of $50 billion for the next decade to create a new generation of strategic aircraft. The B-1B bomber, a variation of the B-1 configuration, has already benefited heavily from NASA support in the design process. A large fraction of the 26,000 hours of wind tunnel time used to develop the B-1 configuration was performed in NASA facilities. We expect to provide comparable support in other defense-related areas such as advanced avionics and the so-called "stealth" technologies. NASA's aeronautics program has been structured to provide full support for those aeronautical programs that are vital to the national security as well as the high priority needs of the commercial aeronautics programs.

The past year was a historic one for the development of new capabilities in space. The first flight of "Columbia" in April was a milestone that marks a fundamental change in the way space operations will be conducted in the future. The second flight in November was the first time that a spacecraft has been reused in its entirety - flown again, and recovered. The original concept of a reusable spacecraft that was developed by NASA in the late 1960's has, therefore, been proved and the Nation can be justifiably proud of this achievement.

We have fully funded the important elements of the Shuttle program in our FY 1983 request. The highest priority we have set for NASA is to complete the development of the Shuttle and to turn it into an operational system. Safety and reliability of flight and the control of operational costs are primary objectives as we move forward with the Shuttle program. We are continuing to take the necessary technical and management steps to make certain that safety will not be compromised and that reliability will exceed that of our current generation of launch vehicles. Cost control is equally important to the viability of the system. This aspect is sharpened by the serious competition for launch services that we now face from abroad.

The steps which we shall take to control the cost of Shuttle operations will fall into two broad categories: first, we will reduce the number of people necessary to conduct Shuttle operations. We believe that this can be accomplished through a number of incremental steps, as we gain flight experience, without compromising safety and reliability. We plan to make a careful analysis of the actions which we must carry out to plan and conduct Shuttle operations. This analysis will include requirements and procedures for flight planning, payload integration, vehicle servicing, test and checkout. We will then be in a position to streamline our civil service and contractor structures to match those requirements. Second, we must reduce the cost of producing the consumable items used for each flight and of refurbishing the items that are reused from flight to flight. The external fuel tanks are perhaps the best example of what we have in mind. We believe that substantial production cost reductions are possible as we make necessary investments to automate production procedures. In other areas I expect flight experience to lead to design changes which will permit operational cost savings.

We have made some significant program reductions in various areas in order to help meet the Administration's objective of fighting inflation by reducing Federal spending. These reductions have been made in those portions of our aeronautics and space applications programs where we believe it is appropriate for the private sector of our economy to play a larger role. It is important to recognize that we have not reduced spending on basic research and technology that could support new initiatives in civil aviation or in space applications. What we have done is to reduce our work in systems technology and in technology demonstration programs in which performance by the private sector appears appropriate.

We have also reduced some of our activities in space science and space exploration. In making these reductions, we have placed the highest priority on work in astronomy and space physics because we believe that discoveries of an unusually important and fundamental nature will soon be forthcoming in these important areas. We have, therefore, funded both the Space Telescope and the Gamma Ray Observatory. There is good reason to believe that the Space Telescope, to be launched in 1985, will be the most important scientific instrument ever flown. Observation of objects such as quasars, Seyfert Galaxies, and the remnants of large supernova events will almost certainly lead to new information about the origin of the universe.

We have retained the Gamma Ray Observatory for launch in 1988 for the same reason--because gamma rays are probably the most sensitive indicators of what happens in objects where very energetic processes are occurring. We have made some reductions in our planetary exploration program, most significantly, deletion of the Venus Orbiting Imaging Radar mission, but we have retained funds for the Galileo mission in the FY 1983 request. The planetary program realized enormous success in the last decade. We believe, however, the time has come to reevaluate this program and to set new direction for the future. Several scientific study groups within and outside NASA are now studying the future of the planetary exploration program. We believe that the outcome of these studies could lead to the development of some less expensive missions for the late 1980's and early 1990's as well as more ambitious concepts such as manned visits to earth-crossing asteroids and perhaps the nearby planets in the years to follow.

As noted earlier, the policies the Administration is developing to shape the future of the American space and aeronautics program are consistent with the National Aeronautics and Space Act. They provide for the retention of two administratively separate activities in space--one related to the national security and another related to essentially civilian activities. While this separation is maintained, we are working actively to strengthen relationships at all levels between NASA and those elements in the national defense establishment for activities in space related to the national security. You will see evidence of this when you examine the details of our program. We strongly support this administrative separation and believe that the arrangement has served the national interest well in the past and will continue to do so in the future.

A fundamental requirement of the Space Act is to preserve the role of the United States as a leader in space technology. For the last decade the major policy objective of the space program has been to provide routine access to space. To implement this policy objective we have created the Space Shuttle. Although we still have much work to do to turn the Shuttle into an operational system, we believe that the time has come to examine some possible new policy objectives and to plan the technological initiatives required to implement them. For example, an operational Space Shuttle leads to the possibility of establishing permanent facilities and a permanent presence in space. We are critically examining the possibility of establishing a permanent presence in space, as a major national initiative in space, and have begun appropriate discussions within the Administration to this end.

Several other policy and institutional issues are currently under review by study groups organized under the auspices of the Office of Science and Technology Policy. These include studies dealing with institutional arrangements in aeronautics and in Space Shuttle operations and with technical questions concerning the stable of launch vehicles that the Nation's space operations will require in the future. We expect that these studies will be completed in the late spring or summer of this year. NASA is well represented and deeply involved in these studies and we believe they will provide a new insight into the national aeronautics and space endeavor.

Finally, I would like to say a word about the NASA organization. In the past six months we have made some organizational changes that will hopefully make it easier for me to spend more time on the major policy questions that I have just outlined. We have improved communications and streamlined overall management control by reducing the number of people who report directly to me. We have consolidated the Offices of Space Science and Space Applications into one organization to strengthen the common technical and management elements inherent in the previously separate organizations. We have broadened the authority and responsibilities of the Program Associate Administrators by having the field centers report directly to them rather than to me. I believe that the organizational steps we have taken will make it possible to delegate authority more readily and improve the overall operation of the organization. In the coming months, we will be taking other organizational steps with these objectives in mind.

Mr. Chairman, I would now like to proceed with an overview of NASA's FY 1983 program.

SPACE TRANSPORTATION SYSTEMS

For Space Transportation Systems the request of $3.468 billion for FY 1983 will move us out of Shuttle development flight test and evaluation and into the initial stages of operations. The past year marked significant gains toward providing the Nation with an operational space transportation system. The key element of this system, the Space Shuttle, has completed two of its four planned orbital flight tests. Both flights, STS-1 and STS-2, were highly successful.

STS-1 accomplished all major flight objectives and demonstrated the viability of the total system. STS-2 fulfilled 90 percent of planned high priority flight objectives, demonstrated the reusability of the orbiter vehicle and its ability to support payload requirements. In both flights, the astronauts reported the orbiter exhibited exceptionally good handling characteristics. The thermal protection system performed better than expected with anomalies well below that expected on first flights. Based on these results, we are approaching the next two orbital flight tests with confidence.

During the current fiscal year we will complete the last two orbital flight tests and accept delivery of the second orbiter vehicle, Challenger, now scheduled for this June. At the Kennedy Space Center prelaunch preparations are underway for STS-3 and the first line of Space Shuttle processing facilities and ground support equipment which supported the STS-1 and STS-2 launches are fully activated and a number of second line processing facilities are nearing completion.

SPACE SHUTTLE

The budget request for Space Shuttle in FY 1983 is $1.718 billion. By the coming fiscal year we will have completed basic development and flight test of the Shuttle and, therefore, are not requesting funds for DDT&E. However, $72.5 million is requested for changes and systems upgrading to initiate modifications to improve reliability, increase operating efficiency and reduce costs. These funds allow for potential changes and systems modifications and unanticipated developments not included in the budget for production.

Our FY 1983 budget request for Space Shuttle production is $1,585.5 million for such activities as the orbiters, main engines, spares and equipment. Manufacturing of orbiters will continue on a schedule consistent with the needs of the Department of Defense and civil users.

For orbiter activities, we are requesting $933.5 million to cover such activities as OV-103 systems installations, factory checkout, and the thermal protection installation. OV-102 will be modified to full operational status; and, OV-104 fabrication and assembly will proceed with major subcontractor effort accounting for much of this activity.

$262 million is required to continue main engine fabrication and assembly of Full Power Level (FPL) flight engines. FPL certification testing will be supported leading to certification of the FPL engines in FY 1983 for ten missions. Life maintenance demonstration testing will be initiated at the completion of FPL certification testing.

For KSC production activities, we are requesting $67 million for design, installation, checkout and validation of the second line processing facilities, including the solid rocket booster segment processing, storage facility, the second launch pad, and the DOD secure firing room.

$323.0 million is being requested for the spares and equipment needed to provide rate tooling to support external tank and solid rocket booster production and the procurement of orbiter flight spares and crew equipment commensurate with the operational flight rate buildup.

We are also requesting $60 million for performance augmentation to enhance Shuttle ascent performance. Some erosion in payload capability and performance margins has occurred as a result of growth in the system's inert weight, particularly in the orbiter. The augmentation of ascent performance is needed to support certain national security missions and, in particular, a scheduled launch from the Western Space and Missile Center in 1985. Alternate performance augmentation studies were previously planned to extend through FY 1982. However, due to early completion of the necessary trade-off analyses and the requirement to initiate development as soon as possible to meet the 1985 mission date, we have selected an approach which will reduce the inert weight of the solid rocket boosters by using filament wound motor case segments to replace the heavier steel cases. A reprogramming request to initiate development is now pending with the Committee to apply study funds previously requested in FY 1982 to initiate development.

Also included in this request is funding to support a demonstration of the space transportation systems's ability to support a mission to retrieve an operating spacecraft and repair it on orbit or return it to earth for refurbishment. It has been determined that the Solar Maximum spacecraft, which is now partially disabled, will serve as the target for this demonstration. This mission would restore this spacecraft to full operational status for further important data gathering.

SPACE FLIGHT OPERATIONS

In Space Flight Operations we are requesting a total of $1.707 billion. Significant accomplishments in the past year include delivery of the Spacelab flight unit, flight of the first scientific payload on STS-2; and, in addition to the two successful Shuttle launches, a perfect record of 11 successful launches using Atlas-Centaur, Scout, Delta and Atlas-F vehicles.

STS operations activities provide continuing support for the integration of the Space Shuttle system, the Spacelab, upper stages and all ground launch and mission control facilities into a versatile and economical overall system to accomplish user mission objectives.

Shuttle operations funding of $1.414 billion constitutes the largest portion of the overall Space Flight Operations budget. It supports a schedule of 5 planned launches in FY 1983, 10 launches in FY 1984 and 13 launches in FY 1985. Activities include mission planning and flight operations, orbiter launch and landing processing, cargo processing and payload integration, and procurement of external tanks, solid rocket boosters and spare equipment. Also included is upper stages operations funding required for the production, delivery and operation of the Air Force Inertial Upper Stage (IUS) and the Solid Spinning Upper Stage (SSUS). Two IUS's during FY 1983 will carry two Tracking and Data Relay Satellites (TDRS) from low-earth to geosynchronous orbit.

STS operations capability development funding of $85.4 million will be used to support upper stage development, multi-mission and payload support equipment, Mission Control Center (MCC) upgrading, payload and operations support and STS operations effectiveness. Multi-mission and payload Support Equipment will be developed into a standard, reusable inventory of equipment which can be used for a variety of payloads. Mission Control Center upgrading funding will be used to reconfigure the MCC at the Johnson Space Center with new equipment and software to support the requirements of the STS operational flight schedule. FY 1983 funding for Payload and Operations Support will be used to support the development and activity of the Payload Operations Control Center at the Johnson Space Center to support NASA Spacelab missions in conjunction with the MCC.

Upper stage vehicles under development are the Inertial Upper Stage (IUS) and the Solid Spinning Upper Stage (SSUS). For FY 1983 we are requesting $32 million for continuing the necessary activities to modify the two-stage IUS for NASA missions.

We are requesting $82.4 million to support the engineering and technical support base, formerly called development, test and mission support. This redefined program activity provides minimal core capability to sustain an engineering and development base to support various Space Transportation Systems programs. This core capability provides basically for a five day, one shift operation of designated institutional research and development facilities. Demands in excess of this support are being funded by the benefiting programs.

FY 1983 funding for STS operations effectiveness will be used to provide for improvements in STS vehicle hardware, vehicle turnaround and cargo processing, mission operations and system software automation. This funding will also support management studies to develop strategies to insure maximum utilization of the STS while reducing the cost and complexity of STS operations and evaluating possible scenarios for future institutionalization of the system.

Most of the $113.2 million funding for Spacelab in FY 1983 will be used to continue the procurement of the second flight unit and spares and to support the first Spacelab mission in late FY 1983. This funding will also be used to continue work on the first Spacelab crew transfer tunnel and to complete the Spacelab simulator at JSC to support crew training for the first mission. In addition, funds will be required for the Spacelab integration contractor to support preparations for the first flight, software using the Software Development Facility at the Marshall Space Flight Center, and to continue integration and checkout of the flight unit hardware and software at KSC.

For advanced programs we are requesting $11.9 million. Major emphasis will be placed on continuing studies, engineering investigations and definition of mission options made possible by the space transportation system. Options include unmanned platforms in both low-earth orbit and geosynchronous orbit, a permanently manned facility in low earth orbit and various support elements.

EXPENDABLE LAUNCH VEHICLES

Our request of $42.8 million for Expendable Launch Vehicles (ELVs) will be used primarily for the Delta launch vehicles to support NASA missions scheduled for launch in FY 1983 and subsequent years. These missions are the Infrared Astronomy Satellite and Landsat-D' launched from the Western Space and Missile Center and the Active Magnetospheric Particle Tracer Explorer launched from the Eastern Space and Missile Center.

Major funding for the ELV program continues to come from the reimbursable users of NASA ELV launch services: the DOD for navigation and communications satellites; and NOAA for weather satellites and a variety of domestic and international commercial communications payloads.

SPACE SCIENCE AND APPLICATIONS

The budget request for Space Science and Applications totals $998.3 million in FY 1983. Although the request is constrained, most of the spacecraft development projects presently underway continue unchanged. The funds will continue, as planned, the development of the Landsat-D advanced remote sensing satellite scheduled for launch later this year. The Space Telescope development is also proceeding on plan for launch in 1985.

The Galileo Jupiter orbiter and probe mission will also be launched in 1985, as planned. However, the launch vehicle will now be the two-stage IUS instead of the Centaur. This change of launch vehicle will require adding a propulsion stage to the Galileo spacecraft and modifying the trajectory so that the spacecraft will pick up energy by means of an earth flyby. The Jupiter arrival date will be delayed by approximately two years with some increase in mission operations costs. The restructured single-spacecraft International Solar Polar Mission will also be launched on a two-stage IUS with an additional propulsion module. The launch date remains in 1986.

Development of the Earth Radiation Budget Experiment is also proceeding smoothly. We will be ready to launch in 1983, though the actual launch dates that NOAA can support are currently under review. We will be prepared to launch our part of the Search and Rescue mission this year. Development of the experiments selected for flight on the Upper Atmosphere Research Satellite will assure, if full development of this mission is approved and initiated, that these instruments will be ready.

The Gamma Ray Observatory will move into its hardware phase for both spacecraft and instruments. Development is still proceeding on a schedule leading to launch in 1988. The Venus Orbiting Imaging Radar mission will not be funded in FY 1982 or FY 1983, in effect cancelling the mission.

Our Shuttle spacelab payloads program is moving ahead well. Payload flights on the STS support virtually the entire scope of science and applications disciplines. The life sciences and materials processing programs rely on the low gravity environment of space to resolve basic physiological and physics questions. Remote earth sensing payloads, such as the Radar Imaging Systems flown on STS-2, utilize the near-earth vantage point of the Shuttle orbit to gain valuable insights on the significance of surface features and the processes that have formed and continue to form our earth. Physics and astronomy payloads use the Shuttle orbiter to look outward from the earth to study the sun and its effects on the Earth and to study phenomena occurring at the outermost reaches of the universe. We are now planning to use Spacelab flights to make detailed observations of Halley's Comet during its apparition in 1986.

In the Explorer program, which recently launched two science and applications research satellites, the Solar Mesosphere Explorer and the Dynamics Explorer, the development of the Infrared Astronomy Satellite and the Active Magnetospheric Particle Tracer Explorer will continue with the launch of the InfraRed Astronomy Satellite now scheduled for later this year. We will soon initiate development of the Cosmic Background Explorer. This series of low cost missions has made and will continue to make major contributions to science and applications objectives, albeit at a somewhat slower pace than anticipated earlier.

Supporting activities included in the request run from major continuing applications projects to balloon, aircraft and sounding rocket flights to small university research efforts. The geodynamics program uses sophisticated ground-based as well as space-based systems to improve our understanding of the dynamic processes occurring at the earth's surface. Research efforts at universities continue the analysis of data from past programs, carry out complementary laboratory and theoretical research, and help us develop new program concepts. The supporting programs also make a substantial contribution in advancing technology so that these future missions can be accomplished. Such technology development ranges from large scale activities such as those in multi-spectral linear array technology to the small efforts in defining individual instrument concepts.

AERONAUTICAL RESEARCH AND TECHNOLOGY

A total of $232 million is requested for Aeronautical Research and Technology. The request will provide for technology advances in all aeronautical disciplines, stressing the technology areas judged to be the most critical. The FY 1983 budget preserves a strong research and technology base in aerodynamics, propulsion, materials and structures, aircraft controls and guidance, and human factors, and maintains the experimental facilities and people dedicated to aeronautics at the NASA research centers.

Advances in fundamental research and technology efforts will be supported in the FY 1983 budget. Nonintrusive experimental test techniques and the development of analytical and computational methods will help us better understand and predict aerodynamic characteristics associated with the flow of air over a variety of aircraft shapes in order to reduce drag and improve performance. Computational methods will be used to predict complex internal flow through rotating blade rows in turbomachinery and to model combustion processes in engines in order to control emissions and better understand the impact of alternative fuels on engine performance. Research will continue on metallic, ceramic, polymer, and composite materials necessary for high-temperature engine applications and lightweight airframe structures; and analytical methods will be used to improve life prediction and better understand and control the dynamic response of complex aircraft and engine structures. Other important advances are expected in electronics, aircraft control system software and architectural concepts and crew station technology necessary to model pilot behavior in a multivariable environment.

Included in the FY 1983 research and technology base are fundamental supersonic research, critical resources technology and advanced guidance and flight controls research. The discipline and vehicle-oriented research and technology base efforts in the various speed regimes will continue to pursue wind-tunnel investigations on advanced aircraft and rotorcraft concepts and technology for future military aircraft, and to examine the effects of promising technology advances individually and in combination.

We will also pursue systems technology efforts in the areas applicable to high-speed and low-speed aircraft. These efforts are directly interdependent with Department of Defense aeronautical research programs and will be the only focused systems technology activity within NASA. The high-speed activity will investigate advanced technology and new configuration approaches in cooperative wind-tunnel and flight research programs with the Air Force, Navy, and Defense Advanced Research Projects Agency (DARPA). Activity in FY 1983 will involve a variety of high-performance aircraft to investigate advanced concepts, including: the Advanced Fighter Technology Integration (AFTI) F-111 aircraft, the AFTI/F-16 aircraft and HiMAT Remotely Piloted Vehicle. The joint NASA/DARPA X-29A Forward Swept Wing flight demonstration program will undergo extensive wind-tunnel tests, computational analysis and ground tests in preparation for flight test in FY 1984.

The low-speed systems technology program will focus on joint NASA/Army rotorcraft technology activities. The rotorcraft effort will include research on new rotor configurations, using the NASA/Army Rotor Systems Research Aircraft, noise technology, full-scale rotor/fuselage interference tests and human factors research.

SPACE RESEARCH AND TECHNOLOGY

The FY 1983 Space Research and Technology request of $123 million will focus on maintaining a strong research and technology base in the disciplinary areas of aerothermodynamics, chemical propulsion, materials and structures, electronics and automation, and space power and electric propulsion. The funding requested will also continue activity in information, spacecraft, and transportation systems research and technology. These efforts are designed to study the interrelationships of discipline technology from an integrated systems point of view and are critical to the successful transition of technology from the laboratory to useful application. In addition, systems-level studies conducted within the research and technology base will continue to focus the disciplines and system research and technology activities in directions which will lead to maximum benefits from available resources. Finally, systems technology programs involving the extension of ground-based research and technology activities to space using Shuttle, Spacelab, and free-flying vehicles will be continued. During FY 1983, a number of space technology experiments will be performed aboard the Shuttle/Spacelab.

As a first step in addressing the future potential for maintenance of permanent manned presence in space, we have initiated an identification of the critical technology requirements to enable design and development of such systems. A Space Station Technology Steering Committee (SSTSC) has been established consisting of representatives from Headquarters and each of the NASA Centers. This Committee is in the process of identifying the top technology challenges and organizing working groups to develop and recommend technology plans that would underlie future options for such initiatives.

ENERGY TECHNOLOGY

NASA's role in the development of advanced technology for terrestrial energy has come at the request of the agencies directly involved in energy research and development and the Congress. We have funded some NASA energy work and supported the energy programs of the Department of Energy and other agencies. With continuing reductions in civil service manpower, these efforts detract somewhat from our ability to carry out our responsibilities for aerospace research. We have attempted to minimize this impact by choosing areas of activity which produce technology advances of potential benefit to aeronautics and space. However, as we look ahead, we find it will be necessary for NASA to phase out of support to energy programs by the end of FY 1983 in order to devote the available manpower to our traditional programs. We will structure our plans such that the investments that have been made will be protected and a smooth transition to new management is carried out where appropriate.

SPACE TRACKING AND DATA SYSTEMS

To meet the requirements of all NASA flight projects, a total of $508.9 million is requested to provide for continuation of vital tracking, command, telemetry and data acquisition support for earth-orbital spacecraft, including all phases of the Space Shuttle flight program, as well as support for planetary missions, sounding rockets and research aircraft. Funds are also required for operations support for the mission control centers, computation and data processing facilities and communications. In addition, beginning in FY 1983, we have included the cost of the initial incremental lease payment for Tracking and Data Relay Satellite System (TDRSS) services.

Our two networks, the Spaceflight Tracking and Data Network (STDN) and the Deep Space Network (DSN) provide worldwide support for both near-earth orbiting satellites and deep space probes such as the encounter of the Voyager II spacecraft with Saturn in August 1981. These networks are preparing for a new era in data gathering capability with the advent of the TDRSS. Approximately fifty spacecraft, including the Space Shuttle and various planetary missions will be supported in FY 1983, along with intensive preparations for upcoming launches of approved programs such as Galileo, Space Telescope, Spacelab and TDRSS.

Some major activities to achieve economies during the past year include the closure of the ground STDN station in Quito, Ecuador, and the Tula Peak special purpose station in New Mexico, as well as a reduction in staffing at a number of tracking stations. Three 26-meter antennas of the Deep Space Network were also closed.

The TDRSS capability is planned to become fully operational in 1984. At that time, the TDRSS will support all low earth-orbit spacecraft which will permit the closing of the majority of the worldwide STDN network. All other space missions, including planetary missions, such as the Voyager II encounter of Uranus in 1986, interplanetary spacecraft, and highly elliptical earth-orbiting missions, will be serviced primarily from existing tracking station facilities in California, Spain, and Australia, which will be consolidated under the management of the Jet Propulsion Laboratory.

TECHNOLOGY UTILIZATION

For FY 1983, we are requesting $4 million for Technology Utilization to continue the transfer of NASA-developed technology to U.S. industry, the public and other Government agencies. This represents a significant reduction from the current FY 1982 level of $8 million. While our primary focus will be on the continuation of active publication and technology dissemination activities, we will increase our efforts to acquire larger user contributions from both the private and public sectors. For example, we plan to continue phase zero feasibility and planning efforts in technology applications to define public sector applications projects in conjunction with other mission-oriented Federal agencies, with the view toward shifting budgetary responsibility for resultant projects to those user agencies. In addition, we will study the possibility of converting NASA Tech Briefs and other publications to paid subscription.

INTERNATIONAL COOPERATIVE ACTIVITIES

During this period of fiscal restraint, no nation can afford to pursue fully all scientific and technological opportunities. As a consequence, the many benefits that result from international cooperation such as access to foreign funds, foreign scientific and technological expertise, and foreign research and development facilities, become even more attractive. The 1980's will be a decade in which NASA will realize the benefits of many international activities begun in the 1970's and will lay the groundwork for new and different forms of cooperation.

During the past year, several important milestones in some of our major cooperative projects were reached. For example, the Remote Manipulator System, which was developed, built and contributed by Canada, was successfully flown for the first time on STS-2. The European Space Agency recently delivered the first Spacelab flight unit to NASA; its maiden flight on the Shuttle is scheduled next year.

An increasing number of foreign nations are now well-equipped to participate fully in the exploration of space. Many have been actively involved for the past decade or more. Investments by foreign governments in space activities have steadily increased and we believe this trend will continue through the 1980's. This has the effect of generating competition in some areas, such as space launch vehicles, communications satellites and remote sensing systems. The United States must be prepared to meet this competition aggressively and we are taking a number of steps to help assure that U.S. space leadership is maintained. However, we need to keep in mind that these same increased capabilities and budgets can make foreign nations attractive as potential partners in future projects where it is in the U.S. interest to share costs or otherwise broaden support for its space activities.

CONSTRUCTION OF FACILITIES

The FY 1983 request for Construction of Facilities of $100 million has been limited to a constrained program that includes only minimum "hardcore" requirements in direct support of ongoing aeronautical and space programs and critical institutional base needs. Less than fifteen percent of the request is for new construction, while the majority of the requirements are for modification, rehabilitation, or repair of existing facilities which will permit better utilization of the present physical plant and preclude some facilities becoming serious repair or replacement problems.

Approximately one-fourth of the funds requested are for the Space Shuttle and payload facilities work. The major requirements are for modifications of the manufacturing plant for the External Tank. These are required to provide a higher production rate capability than is presently available.

Major facility projects required for adequate support of aeronautical research and development comprise approximately $26 million of this request. These include modifications of two key wind tunnels at the Langley Research Center to improve testing precision and productivity.

The budget request also includes the continuing minor facilities work (minor construction, repair, and rehabilitation and modifications) that is critical to preserving the unique research and development capabilities of the NASA physical plant.

RESEARCH AND PROGRAM MANAGEMENT

The Research and Program Management request for FY 1983 is $1,178.9 million. About three-fourths of this account is required for civil service personnel salaries and related costs. About two percent is for travel which is vital to the management of our research and development programs. The balance is for facility support and related goods and services.

In 1981 two major institutional changes were implemented to improve the efficiency and effectiveness of operations. Last spring, Dryden Flight Research Center was made an integral part of the Ames Research Center, and the Wallops Flight Center part of the Goddard Space Flight Center. These actions were taken to focus the resources of each installation on what it can do best. The close relationship between Ames' and Dryden's efforts in aeronautical programs and Wallops' and Goddard's efforts in sounding rocket and airborne experiment programs provide an opportunity to improve overall program effectiveness through these consolidations.

Last fall an organizational change was made in Headquarters to assure the proper delegation of authority to all line managers, to set forth a clear distinction between line and staff, and to simplify and clarify field centers' reporting lines. The chief institutional change was to place centers under the managerial control of the program office from which they had already been receiving most of their programmatic directions. The Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center and the National Space Technology Laboratories report to the Associate Administrator for Space Transportation Systems; the Ames Research Center, the Langley Research Center and the Lewis Research Center to the Associate Administrator for Aeronautics and Space Technology; and the Goddard Space Flight Center to the Associate Administrator for Space Science and Applications.

In FY 1982, we are reducing our permanent civil service work force by 221 below the amended 1982 budget. This brings the civil service reduction from the original 1982 plan submitted a year ago to 1,061, a reduction of almost 5 percent. In 1983, we will reduce the permanent civil service work force by another 433, and NASA will be at its lowest civil service complement in over 20 years. We believe that we can achieve these reductions in a manner to minimize detrimental impacts, on NASA's programs and capabilities and on the individuals involved, while supporting fully our national commitments.

Requested increases, other than those for personnel and related costs, reflect only the amounts required to meet expected FY 1983 levels for support service contractor wage rates, utility rates and price levels for supplies, materials, equipment and other purchased services.

Even with significant civil service personnel reductions, NASA has been able to improve the ratio of minority and female professional employees in the Agency work force. In 1981, the ratio of minority professionals rose from 8.1 percent to 11.6 percent. Consequently, minority and female professionals now make up 20 percent of NASA's professional work force and 28.5 percent of the total work force.

CONCLUSION

In conclusion, this request represents a program which supports the major priorities of the Administration. It fully funds the Space Shuttle program and those aeronautics and space efforts related to national security while deferring or eliminating programs which could be performed by the private sector. In this context I believe it represents a balanced program which will provide the basis for future programs to exploit the full potential of the Space Transportation System.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BUDGET SUMMARY
(Thousands of Dollars)

		Budget Plan	
RESEARCH AND DEVELOPMENT	FY 1981	FY 1982	FY 1983
Space Transportation Systems	2,728,600	3,090,100	3,467,800
Space Shuttle	1,995,000	2,163,000	1,718,000
Space flight operations	679,200	895,900	1,707,000
Expendable launch vehicles	54,400	31,200	42,800
Space Science	541,488	568,000	682,000
Physics and astronomy	323,700	323,500	471,700
Planetary exploration	175,600	205,000	154,600
Life sciences	42,188	39,500	55,700
Space and Terrestrial Applications	340,350	333,800	320,300
Space applications	331,550	325,800	316,300
Technology utilization	8,800	8,000	4,000
Aeronautics and Space Technology	384,000	344,000	355,000
Aeronautical research and technology	271,400	233,000	232,000
Space research and technology	110,700	111,000	123,000
Energy	1,900	---	---
Tracking and Data Acquisition	339,900a/	402,100a/	508,900
TOTAL RESEARCH AND DEVELOPMENT	4,334.338	4,738,000	5,334,000
CONSTRUCTION OF FACILITIES	116,950a/	98,700a/	100,000
RESEARCH AND PROGRAM MANAGEMENT	1,071,064	1,144,700b/	1,178,900
TOTAL	5,522,352	5,981,400	6,612,900
OUTLAYS	5,421,300	5,826,500	6,576,100

a/ Reflects reprogramming of R&D funds to CoF: 1981 program $1.2M, 1982 program $2.9M.
b/ Includes increased pay costs of $41.4M.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR SCHMITT AND THE ANSWERS THERETO

US AND USSR SPACE FLIGHT ACTIVITIES

Question: During previous hearings you provided charts summarizing the US and USSR space flight activities since the late 1950's. Please update these charts and submit these for the record.

Answer: Enclosed are the updated charts - B-4, B-5, B-6, and B-7.

UNIVERSITY BASIC RESEARCH

Question: Would you please update for the record NASA's support of basic research in the universities, including obligations in current and constant dollars, as a percentage of NASA appropriations and by type of effort.

Answer: Enclosed are updated versions of the tables (A-E) NASA has been providing for the past several years. They are extracted from our annual "Summary University Program Information Document." Individual tables cover:

- Total NASA obligations to universities 1959-1983
- Obligations as percentage of appropriations
- Current and constant dollars
- Obligations by type of research (including basic)
- Obligations for basic research by field science or technology

Question: Would you please update, for the record, NASA's total budget history from 1966 to the present in both graphical and tabular form in the real year and constant dollars? Please also update NASA's manpower history including civil service employees, in-house contract support and external contractor support.

Answer: See Charts A-D enclosed.

NASA CIVIL SERVICE WORK FORCE

Question: Continuous reduction of the NASA civil service work force in recent years has caused a significant increase in average age. At the same time attrition due to early retirement and noncompetitive salaries has caused the loss of considerable expertise and "corporate memory" from the agency. What is NASA doing to ensure that it has the correct skill mixes for its future programs as well as an adequate balance between seasoned veterans and young persons with new ideas? Please give your assessment of the problem of retention of experienced managers at the GS-15 and SES levels; and specifically, how would you assess the success to date of the Senior Executive Service bonus system?

WORK FORCE BALANCE

Answer: Since 1967, NASA personnel strength has been reduced every year, decreasing from 33,947 to 21,652. There is a further projected decrease in FY 1983 to 21,219. These reductions in NASA strength have made it very difficult to maintain a balance of skills

Summary Of USA & USSR Announced Launches

Calendar Year — NUMBER OF SUCCESSFUL LAUNCHES

	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	Total
NASA	0	0	8	10	16	20	11	24	23	29	18	12	13	7	7	9	9	3	11	2	3	8	3	1	4	251
NASA/USA Gov't	0	0	0	0	0	0	2	1	1	4	3	3	1	1	1	2	2	1	2	3	2	2	3	3	4	41
NASA/Commercial	0	0	0	0	0	1	1	0	1	1	3	1	2	3	2	2	1	3	3	7	1	3	2	2	5	44
NASA/International	0	0	0	0	0	2	0	2	1	0	2	3	4	2	6	5	1	8	3	4	7	7	1	0	0	58
TOTAL NASA	0	0	8	10	16	23	14	27	26	34	26	19	20	13	16	18	13	15	19	16	13	20	9	6	13	394
Air Force	0	1	5	8	16	31	24	31	34	39	27	25	18	16	17	13	10	8	9	11	10	13	7	6	5	384
Navy	0	1	0	2	3	3	4	4	5	4	4	1	1	1	0	0	0	0	0	0	0	0	0	0	0	33
Army	0	3	0	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
TOTAL DOD	0	5	5	11	19	34	28	35	40	43	32	26	19	17	17	13	10	8	9	11	10	13	7	6	5	423
TOTAL USA SUCCESSES	0	5	13	21	35	57	42	62	66	77	58	45	39	30	33	31	23	23	28	27	23	33	16	12	18	817
TOTAL USSR	2	1	3	3	6	20	17	30	48	44	66	74	70	81	83	74	86	81	89	99	98	88	87	89	98	1437

NUMBER OF UNSUCCESSFUL LAUNCHES (Not included in numbers above)

	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	Total
NASA	0	4	6	7	8	4	1	3	4	2	1	3	1	1	1	0	0	1	1	0	0	0	0	0	0	48
NASA/USA Gov't	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	3
NASA/USA Commercial	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	4
NASA/International	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2	0	0	0	0	4
Total NASA Unsuccessful	0	4	6	7	8	4	1	3	4	2	2	4	2	1	2	0	1	2	2	0	3	0	0	1	0	59
Total DOD Unsuccessful	1	8	4	8	7	6	8	5	4	3	2	1	0	0	2	2	0	0	1	0	0	1	0	2	1	66

Chart B-4

Successful USA & USSR Announced Launches

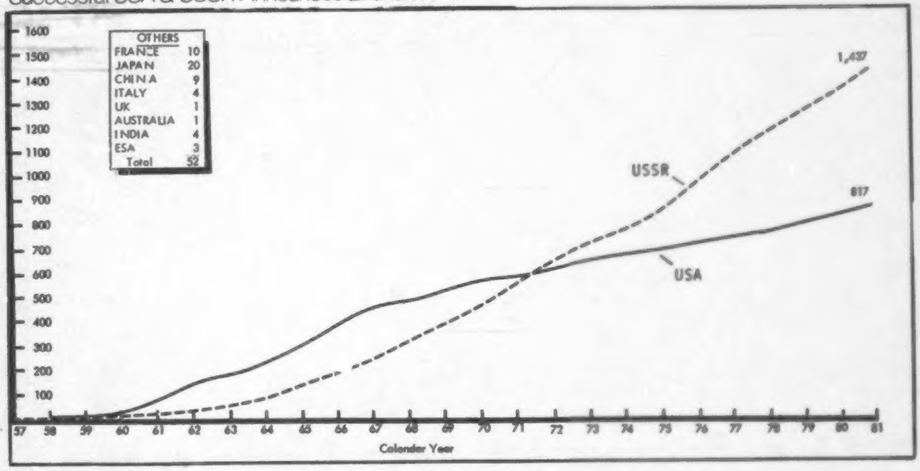


Chart B-5

Summary Of USA & USSR Announced Payloads

	Calendar Year																									
	NUMBER OF SUCCESSFUL MISSIONS OR PAYLOADS																									
	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	Total
NASA	0	0	8	9	15	17	10	23	22	19	17	13	11	5	7	9	8	3	11	2	3	8	3	1	4	228
NASA/USA Gov't	0	0	0	0	0	0	2	1	1	4	3	3	1	1	1	2	2	1	2	3	2	2	3	3	4	41
NASA/USA Commercial	0	0	0	0	0	1	1	0	1	0	3	1	2	2	2	2	1	3	3	7	1	3	1	2	5	41
NASA/International	0	0	0	0	0	2	0	2	2	0	2	3	4	2	6	5	1	9	3	4	8	7	1	0	0	61
TOTAL NASA	0	0	8	9	15	20	13	26	26	23	25	20	18	10	16	18	12	16	19	16	14	20	8	6	13	371
Air Force	0	1	5	8	18	33	39	39	49	63	48	42	29	20	31	17	12	7	11	18	14	14	9	9	5	541
Navy	0	1	0	3	7	7	10	11	15	4	12	1	10	1	0	0	0	1	0	0	0	0	0	0	0	83
Army	0	3	0	1	0	0	0	0	4	3	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	14
TOTAL DOD	9	5	5	12	25	40	49	58	68	70	61	43	40	22	31	17	12	8	11	18	14	14	9	9	5	a/ 638
TOTAL USA SUCCESSES	0	5	13	21	40	60	62	76	94	93	86	63	58	32	47	35	24	24	30	34	28	34	17	15	18	1009
TOTAL USSR	2	1	3	3	6	20	17	35	64	44	66	74	70	88	97	89	107	95	111	121	105	120	102	110	125	1675
	NUMBER OF UNSUCCESSFUL MISSIONS OR PAYLOADS (Not included in numbers above)																									
NASA	0	4	6	8	9	7	2	5	5	7	2	3	3	3	1	0	0	1	1	0	0	0	0	0	0	67
NASA/USA Gov't	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	3
NASA/USA Commercial	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	1	0	1	0	1	0	0	7
NASA/International	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	2	0	0	0	0	4
Total NASA Unsuccessful	0	4	6	8	9	7	2	5	5	8	3	4	4	4	2	0	1	2	2	0	3	0	1	1	0	81
Total DOD Unsuccessful	1	8	4	8	7	6	8	5	4	3	2	1	0	0	2	2	0	0	1	0	0	2	0	4	1	69

a/ Subject to change as DOD payloads become unclassified

Chart B-6

Successful USA & USSR Announced Payloads

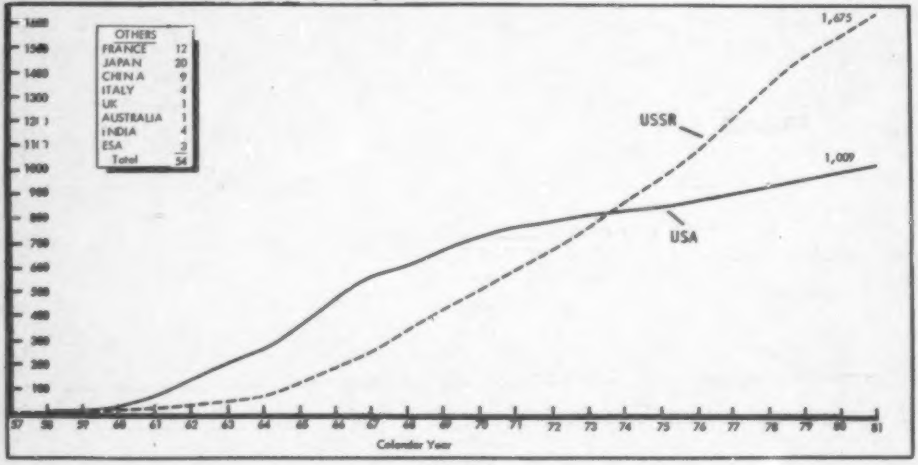
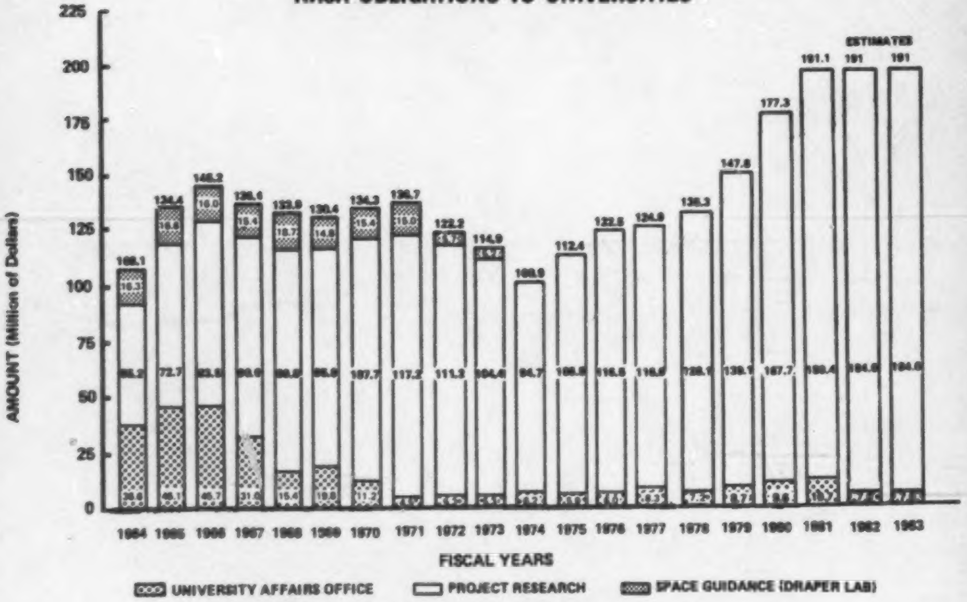


Chart B-7

NASA OBLIGATIONS TO UNIVERSITIES

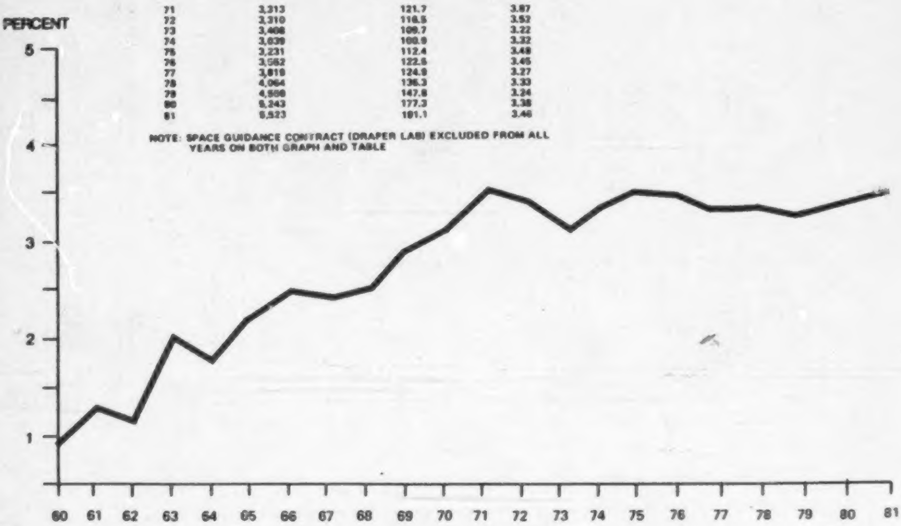


NOTES:
1. Excludes obligations to or through Federally Funded Research and Development Centers (e.g. JPL)
2. Change in status from "university" to "non-profit" for three organizations accounts for $10.1M of the difference between FY 73 and FY 74. (Draper Lab, ERIM, Dudley Observatory).
3. University Affairs Office includes 1962-1971 Sustaining University Program.
4. Omitted Obligations: Transition Period (July-Sept 1976). $27.7M; FY 79, $3.6M; FY80, $6.0M; FY 81, $14.5M; FY82, $29.5M; FY83, $67.4M.

Source: NASA University Affairs Office

TABLE A

OBLIGATIONS TO UNIVERSITIES AS A PERCENTAGE OF NASA APPROPRIATIONS



FY 71-81 DATA

FISCAL YEAR	APPROPRIATIONS ($ MILLIONS)	OBLIGATIONS ($ MILLIONS)	PERCENT OF APPROPRIATIONS
71	3,313	121.7	3.67
72	3,310	116.5	3.52
73	3,406	109.7	3.22
74	3,039	100.9	3.32
75	3,231	112.4	3.48
76	3,552	122.6	3.45
77	3,818	124.9	3.27
78	4,064	135.3	3.33
79	4,560	147.8	3.24
80	5,243	177.3	3.38
81	5,523	191.1	3.46

NOTE: SPACE GUIDANCE CONTRACT (DRAPER LAB) EXCLUDED FROM ALL YEARS ON BOTH GRAPH AND TABLE

Table B

NASA OBLIGATIONS TO EDUCATIONAL INSTITUTIONS IN CURRENT AND CONSTANT DOLLARS

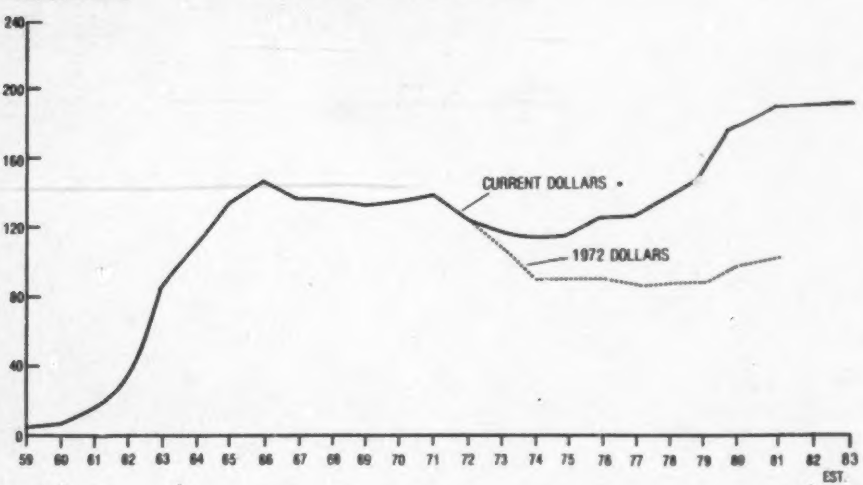


TABLE C

FY 77 - 81 NASA OBLIGATIONS TO EDUCATIONAL INSTITUTIONS

BY TYPE OF EFFORT

Type	Obligations ($Millions)					Number of Projects					Number of Institutions					Percent of NASA Obligations to Universities					Percent NASA Appropriations				
	FY 77	FY 78	FY 79	FY 80	FY 81	FY 77	FY 78	FY 79	FY 80	FY 81	FY 77	FY 78	FY 79	FY 80	FY 81	FY 77	FY 78	FY 79	FY 80	FY 81	FY 77	FY 78	FY 79	FY 80	FY 81
Basic Research	72.0	88.3	96.8	112.8	124.4	1,266	1,476	1,686	1,898	1,884	208	216	233	246	250	58	65	66	64	65	1.89	2.17	2.12	2.15	2.25
Applied Research	33.1	28.0	28.5	33.3	32.7	617	460	405	453	427	175	155	128	137	137	26	21	19	19	17	0.86	0.69	0.63	0.64	0.59
Development	8.6	8.2	11.9	15.2	16.7	72	61	61	67	59	40	43	39	44	49	7	6	8	8	9	0.23	0.20	0.26	0.29	0.30
Total R&D	113.7	124.5	137.2	161.3	173.9	1,955	1,997	2,152	2,418	2,370	253	249	295	264	269	91	92	93	91	91	2.98	3.06	3.01	3.08	3.15
R&D Related	7.2	5.7	6.8	9.9	9.6	75	68	85	131	164	61	54	56	83	75	6	4	4	6	5	0.19	0.14	0.15	0.19	0.17
Foreign	4.0	5.1	3.0	6.1	7.6	9	6	7	7	12	8	6	6	6	10	3	4	3	3	4	0.10	0.13	0.08	0.12	0.14
NASA Totals	124.9	135.3	147.0	177.3	191.1	2,039	2,071	2,244	2,556	2,546	269	264	269	295	287	100	100	100	100	100	3.27	3.33	3.24	3.39	3.46

NOTES: 1. Detail may not add to totals due to rounding.

2. "Institutions" column subtotals and totals are unduplicated counts; therefore, detail cannot add to totals.

Source: NASA, University Affairs Office

TABLE D

BASIC RESEARCH: COMPARISON OF NASA OBLIGATIONS BY C.A.S.E. FIELDS OF SCIENCE AND TECHNOLOGY

	FY Obligations ($M)				
	77	78	79	80	81
Physical Sciences	32.6	39.8	41.7	44.0	48.6
Astronomy	15.4	17.3	18.8	22.0	22.0
Chemistry	3.7	3.4	3.7	3.9	5.4
Physics	10.0	14.7	14.8	14.2	17.1
Physical Sciences, NEC*	3.5	4.3	4.4	3.9	4.1
Mathematics/Computer Sci	0.8	1.0	1.1	1.8	1.9
Mathematics	0.5	0.7	0.9	1.2	0.8
Computer Sciences	0.3	0.4	0.1	0.5	0.4
Math/Computers, NEC*	—	—	—	0.1	0.7
Environmental Sciences	21.5	26.0	29.3	35.3	38.2
Atmospheric Sciences	10.8	13.5	14.5	19.8	22.1
Geological Sciences	6.7	8.4	10.0	10.9	11.4
Oceanography	0.2	0.2	0.5	0.6	1.2
Environmental Sciences, NEC*	3.8	3.9	4.3	4.0	3.4
Engineering Sciences	10.6	14.8	16.6	22.1	24.4
Aeronautical	5.1	7.2	8.3	10.5	11.9
Astronautical	0.4	0.5	0.7	1.0	0.8
Chemical	0.1	0.1	0.1	0.2	0.3
Civil	**	**	0.1	0.1	0.1
Electrical	1.0	1.2	1.7	1.9	2.3
Mechanical	0.4	1.0	0.9	1.4	1.8
Metallurgy	2.6	3.6	3.2	5.1	5.3
Engineering, NEC*	1.1	1.3	1.6	1.9	1.9
Life Sciences	4.6	5.3	5.8	7.4	8.3
Biological Sciences	2.5	3.4	2.3	3.5	4.0
Environmental Biology	—	—	0.3	0.3	0.5
Agricultural Sciences	—	—	—	0.1	0.3
Medical Sciences	—	—	1.2	1.3	1.2
Clinical Medical	0.3	0.2	—	—	—
Other Medical	1.0	0.7	—	—	—
Life Sciences, NEC*	0.8	1.0	2.0	2.2	2.1
Other	1.9	1.8	2.3	2.1	3.0
TOTAL BASIC OBLIGATIONS	72.0	88.3	96.8	112.8	124.4

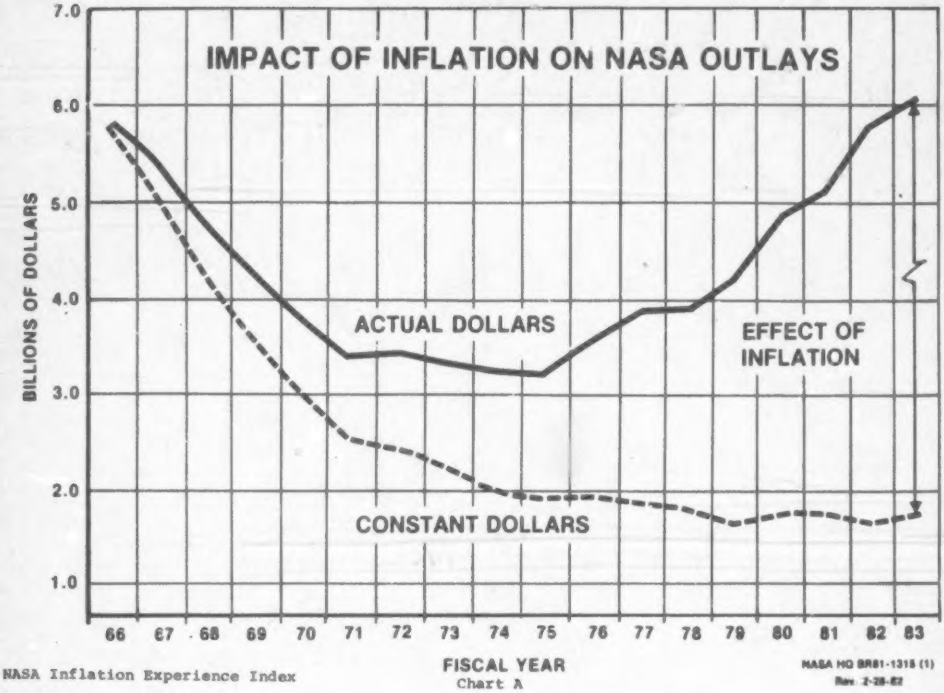
*Not elsewhere classified. Includes multidisciplinary projects and projects for which there is no separate discipline name on the C.A.S.E. list.
**Less than $50K.

Note: Detail does not add to totals due to rounding.

Source: NASA, University Affairs Office

TABLE E

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



NASA Inflation Experience Index

Chart A

IMPACT OF INFLATION ON NASA OUTLAYS
(Billions of Dollars)

FY	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Outlays	5.9	5.4	4.7	4.3	3.8	3.4	3.4	3.3	3.3	3.3	3.7	3.9	4.0	4.2	4.9	5.4	5.8	6.6
Constant FY 1966 $	5.9	5.1	4.2	3.6	3.0	2.5	2.4	2.2	2.0	1.9	1.9	1.9	1.8	1.7	1.8	1.8	1.7	1.8

CHART B

04/15/82

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

(Dollar amounts in millions)

FISCAL YEAR	CIVIL SERVANTS AUTHORIZED (1)	CIVIL SERVANTS EMPLOYMENT (1)	FULL-TIME PERMANENT	OTHER THAN FULL-TIME PERMANENT	SUPPORT SERVICE CONTRACTORS TOTAL (2)	IN-HOUSE (2)	OPERATIONS (2)	R&PM EXPENDITURES (3)	TOTAL NASA EXPENDITURES
1966	36,441	35,708	33,924	1,784	22,432	N/A	N/A	$ 619.4	$5,932.0
1967	35,908	35,860	33,726	2,134	25,527	N/A	N/A	$ 649.0	$5,425.7
1968	35,127	34,641	32,471	2,170	29,281	N/A	N/A	$ 651.9	$4,723.7
1969	34,160	33,929	31,745	2,184	27,759	N/A	N/A	$ 656.2	$4,251.7
1970	33,444	33,317	31,223	2,094	24,305	N/A	N/A	$ 707.2	$3,753.1
1971	32,150	31,329	29,478	1,851	23,117	N/A	N/A	$ 707.8	$3,381.0
1972	29,800	29,016	27,428	1,588	22,198	N/A	N/A	$ 740.4	$3,422.0
1973	29,199	27,175	25,955	1,220	22,378	N/A	N/A	$ 729.1	$3,315.2
1974	27,232	26,507	24,854	1,653	19,820	N/A	N/A	$ 759.5	$3,256.2
1975	25,711	25,638	24,333	1,305	18,433	N/A	N/A	$ 760.8	$3,266.5
1976	25,711	25,426	24,039	1,387	17,428	N/A	N/A	$ 789.3	$3,669.0
1977	25,031	24,188	23,569	619	20,572	(12,734)	(7,838)	$ 859.7	$3,945.3
1978	24,632	23,779	23,169	610	19,041	(12,177)	(6,864)	$ 870.2	$3,983.1
1979	24,191	23,360	22,633	727	19,728	(12,721)	(7,007)	$ 925.0	$4,196.5
1980	23,947	23,947	22,613	1,334	20,946	(13,279)	(7,667)	$1,003.8	$5,012.6
1981	23,017	23,017	21,873	1,144	20,308	(12,781)	(7,527)	$1,071.4	$5,425.6
(4) 1982	23,034	23,034	21,652	1,382	20,588	(12,856)	(7,732)	$1,103.3	$5,831.0
(4) 1983	22,601	22,601	21,219	1,382	21,649	(10,885)	(10,764)	$1,178.9	$6,592.0

(1) Includes both permanent and temporary positions.

(2) In 1977, a study conducted in NASA resulted in a major change in the way contractor support is counted. The support contractor numbers for 1977 and beyond reflect this change in methodology.

(3) Does not include trust fund or offsetting receipts accounts.

(4) Estimates.

CHART C

04/15/82

NASA EMPLOYMENT HISTORY

Fiscal Year	NASA Civil Service Employees	In-House Support Contractors R&D	R&PM	Total	Operations Support R&D	Other Contractors	Total Employment
(1) 1961	17,077	N/A	N/A	N/A	N/A	57,500	74,577
(1) 1962	22,156	N/A	N/A	N/A	N/A	115,500	137,656
(1) 1963	27,904	N/A	N/A	N/A	N/A	218,400	246,304
1964	31,984	8,731	4,880	13,611	N/A	333,489	379,084
1965	33,200	9,468	6,048	15,516	N/A	361,184	409,900
1966	33,924	14,272	8,160	22,432	N/A	337,568	393,924
1967	33,726	16,996	8,531	25,527	N/A	247,673	306,926
1968	32,471	20,543	8,738	29,281	N/A	206,119	267,871
1969	31,745	19,890	7,869	27,759	N/A	158,861	218,365
1970	31,223	16,760	7,545	24,305	N/A	112,275	167,803
1971	29,478	16,532	6,585	23,117	N/A	97,014	149,609
1972	27,428	16,077	6,121	22,198	N/A	95,342	144,968
1973	25,955	16,707	5,671	22,378	N/A	85,722	134,055
1974	24,854	14,433	5,387	19,820	N/A	80,380	125,054
1975	24,333	13,381	5,052	18,433	N/A	84,967	127,733
1976	24,039	12,826	4,602	17,428	N/A	90,572	132,039
(2) 1977	23,569	8,636	4,098	12,734	7,838	79,928	124,069
(2) 1978	23,169	8,168	4,009	12,177	6,864	82,359	124,569
(2) 1979	22,633	8,681	4,040	12,721	7,007	89,570	131,931
(2) 1980	22,613	8,999	4,280	13,279	7,667	98,754	142,313
(2) 1981	21,873	8,515	4,266	12,781	7,527	96,632	138,813
(2) 1982	21,652	8,478	4,378	12,856	7,732	97,833	139,073
(2) 1983	21,219	6,534	4,351	10,885	10,764	85,351	128,219

(1) Total contractor employment only, support contractor data not separately available.

(2) In 1977, a study conducted in NASA resulted in a major change in the way contractor support is counted. The support contractor numbers for 1977 and beyond reflect this change in methodology.

CHART D

and experience in the work force. Throughout this period NASA has continually sought ways to perform its programmatic responsibilities as effectively and economically as possible; through internal reallocation and realignment of resources, efficient use of contractor support and to the extent possible, focused recruitment. Our past efforts to maintain a balanced skill and experience mix were less than successful when we were unable to totally replace attrition losses. Between FY 1968 and FY 1981 our average age rose from 39.4 to 43.8. In FY 1980, however, when replacements approximated losses, our average age dropped from 44.3 to 43.5. Our best means of maintaining a balanced skill and experience mix is to take in a high percentage of recent college graduates in appropriate fields to replace losses. Since FY 1977, 40 percent of our permanent science and engineering hires have been at the GS-7 bachelor degree entry level. We expect that the percentage of entry level hiring in the future will remain at this level or higher.

RETENTION

There are several factors that impact the level of attrition of experienced workers.

One factor is the long history of personnel reductions and program reductions or stretchouts in NASA that extend back to the 1960's. Top technical talent is attracted to programs that are relatively stable and are likely to be carried through to completion.

The pay ceiling and the artificially low Federal pay scale are also significant factors. Employees have increasing concerns about personal finances and the ability to afford college tuition for their children which are beginning to outweigh the intangible rewards of public service. This has particular impact among senior scientists and engineers with experience that is of particular value in the private sector.

Another factor is the negative perception that has been building for the past several years of the Federal service in general. Many signals that come from the general public, their elected representatives and the media are negative toward the civil servants and the work they perform. Examples of actions contributing to this perception include the continuation of pay caps, the potential reduction in retirement benefits, lower health benefits, and severe travel restrictions that limit scientists' and engineers' participation in professional activities.

The combination of these factors produces a powerful disincentive to Federal employment, even with NASA.

SES BONUSES AND INCENTIVE PAY FOR GS-15 MANAGERS

Our experience with the SES Bonus System has not been completely positive. While we have been able to implement the program, the restrictions placed on the system, both in the law and in OPM implementing regulations are severely limiting. In May 1980, we awarded bonuses to 240 Senior Executives in accordance with the then applicable law and regulation, and with the knowledge of the Office of Personnel Management (OPM). In late FY 1980, Congress took action to restrict bonuses to a 25 percent maximum of the SES work force. OPM further reduced this to 20 percent of SES positions. Further, in FY 1982 OPM restricted the bonuses to 20 percent of the on-board SES strength. This limits the NASA ability to use the bonus system as a motivational management tool. This puts us in the position where only a small number of our executives can be recognized with a bonus, even in the year that we first flew the Space Shuttle. Needless to say, this has reduced our capability to motivate and reward our people and increases the probability of key people leaving NASA. It would be preferable to return to the original 50 percent limitation on the number of bonuses or to a system with no limitation on the number of bonuses, but with a total dollar control.

An extension of the SES bonus problems is reflected in our experience with the Merit Pay System for managers and supervisors GS-13/15. Our first payout under the System resulted in many merit pay employees (including those who exceeded performance requirements for their jobs) receiving significantly lower rates of pay than similarly graded employees not under the Merit Pay System.

In NASA these pay inequities are unusually severe because of our parallel career ladders which enable scientists and engineers to reach grades GS-13, GS-14, and GS-15 through their individual accomplishments as well as through the managerial ranks, and two-thirds of our employees at the GS-13/15 grade levels are not managers or supervisors, and thus, not covered by merit pay. The one-third of our employees at these grades who are managers or supervisors possess the unusual combination of technical expertise and managerial ability which has long been a major strength of this Agency and which makes any pay inequity for this group a serious problem for NASA. Unless these inequities are corrected, our ability to retain our experienced managers may be further eroded.

NASA ORGANIZATION

Question: Would you please provide for the record a current organizational chart for NASA Headquarters, for the NASA centers and for the Jet Propulsion Laboratory?

Answer: See enclosed organizational charts.

SPACE PLATFORM FUNDING

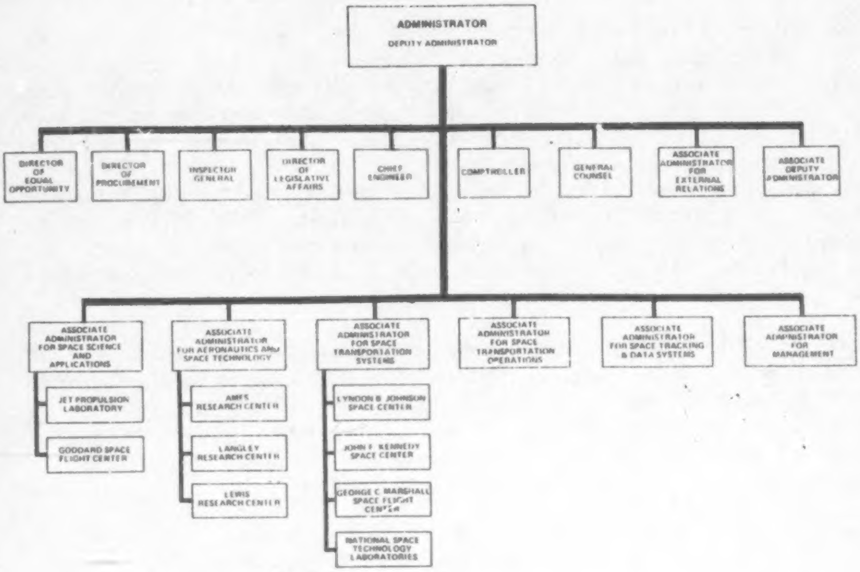
Question: What is the total amount being spent during FY 1982 and proposed for FY 1983 in space platform and platform related activities.

Answer: In FY 1982 NASA plans to obligate approximately $3.0 million for Space Platform studies. This is consistent with the reprogramming letter forwarded to Congress February 4, 1982.

In FY 1983, NASA plans to obligate $1.0 - $1.5 million for Space Platform studies.

STUDENT PARTICIPATION PROGRAMS

Question: Could you provide for the record a summary of student participation programs?


ADMINISTRATOR
DEPUTY ADMINISTRATOR
DIRECTOR OF EQUAL OPPORTUNITY
DIRECTOR OF PROCUREMENT
INSPECTOR GENERAL
DIRECTOR OF LEGISLATIVE AFFAIRS
CHIEF ENGINEER
COMPTROLLER
GENERAL COUNSEL
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS
ASSOCIATE DEPUTY ADMINISTRATOR
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
AMES RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEMS
LYNDON B JOHNSON SPACE CENTER
JOHN F KENNEDY SPACE CENTER
GEORGE C MARSHALL SPACE FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION OPERATIONS
ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING & DATA SYSTEMS
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

December 3, 1981

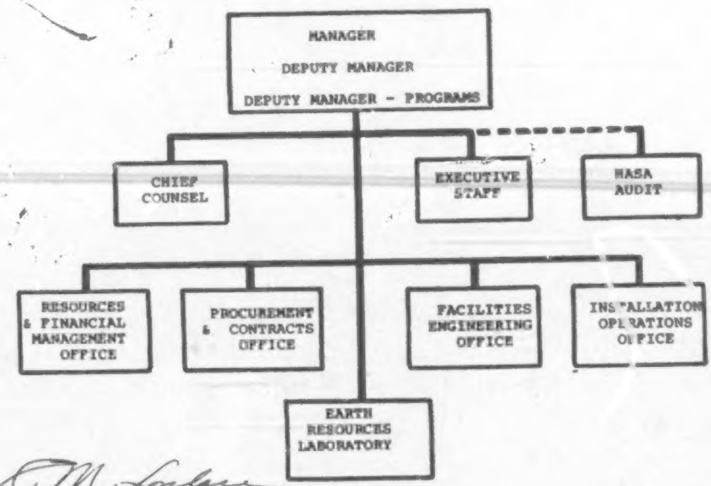
ATTACHMENT A
NMI 1132.2V

APPROVED

DATE December 3, 1981

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NATIONAL SPACE TECHNOLOGY LABORATORIES


MANAGER
DEPUTY MANAGER
DEPUTY MANAGER - PROGRAMS
CHIEF COUNSEL
EXECUTIVE STAFF
NASA AUDIT
RESOURCES & FINANCIAL MANAGEMENT OFFICE
PROCUREMENT & CONTRACTS OFFICE
FACILITIES ENGINEERING OFFICE
INSTALLATION OPERATIONS OFFICE
EARTH RESOURCES LABORATORY

January 10, 1979

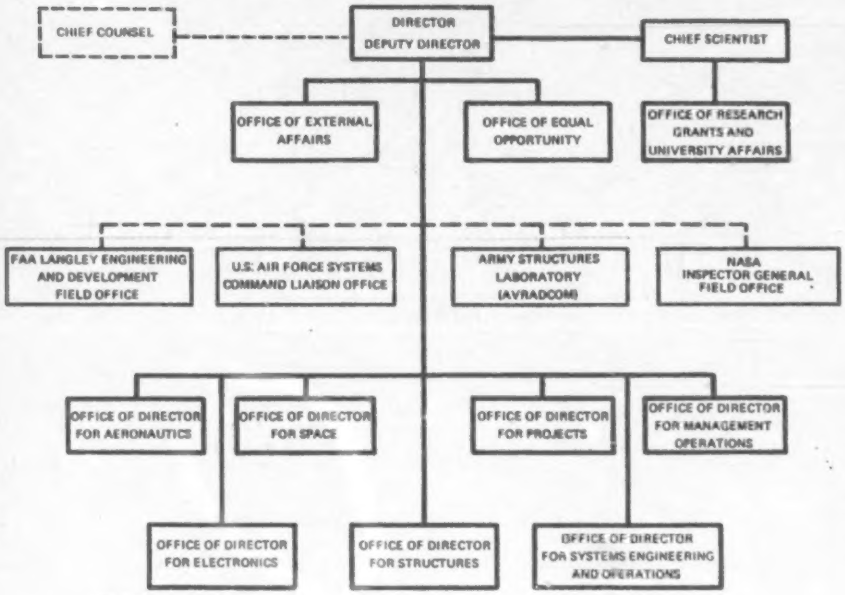
ATTACHMENT A
NMI 1107.1B

Approved:

Date: 1/10/79

LANGLEY RESEARCH CENTER

November 3, 1980


CHIEF COUNSEL
DIRECTOR
DEPUTY DIRECTOR
CHIEF SCIENTIST
OFFICE OF EXTERNAL AFFAIRS
OFFICE OF EQUAL OPPORTUNITY
OFFICE OF RESEARCH GRANTS AND UNIVERSITY AFFAIRS
FAA LANGLEY ENGINEERING AND DEVELOPMENT FIELD OFFICE
U.S. AIR FORCE SYSTEMS COMMAND LIAISON OFFICE
ARMY STRUCTURES LABORATORY (AVRADCOM)
NASA INSPECTOR GENERAL FIELD OFFICE
OFFICE OF DIRECTOR FOR AERONAUTICS
OFFICE OF DIRECTOR FOR SPACE
OFFICE OF DIRECTOR FOR PROJECTS
OFFICE OF DIRECTOR FOR MANAGEMENT OPERATIONS
OFFICE OF DIRECTOR FOR ELECTRONICS
OFFICE OF DIRECTOR FOR STRUCTURES
OFFICE OF DIRECTOR FOR SYSTEMS ENGINEERING AND OPERATIONS

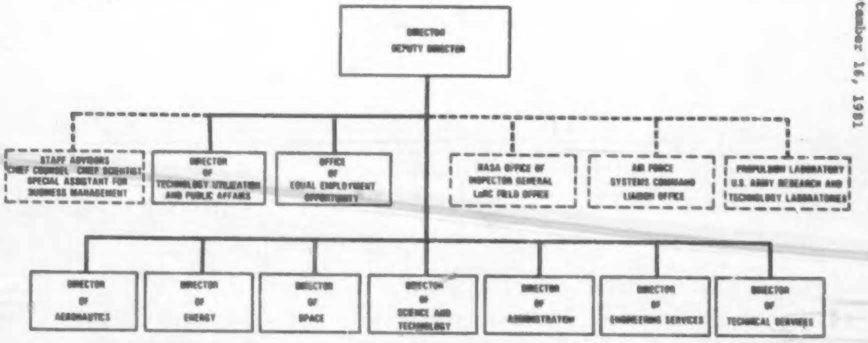
APPROVED: A. M. Lovelace
DATE: 11/3/80

ATTACHMENT A
NMI 1107.2 Ch. 1

NASA
National Aeronautics and
Space Administration

LEWIS RESEARCH CENTER

September 16, 1981


DIRECTOR
DEPUTY DIRECTOR
STAFF ADVISORS
CHIEF COUNSEL CHIEF SCIENTIST
SPECIAL ASSISTANT FOR BUSINESS MANAGEMENT
DIRECTOR OF TECHNOLOGY UTILIZATION AND PUBLIC AFFAIRS
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NASA OFFICE OF INSPECTOR GENERAL LeRC FIELD OFFICE
AIR FORCE SYSTEMS COMMAND LIAISON OFFICE
PROPULSION LABORATORY
U.S. ARMY RESEARCH AND TECHNOLOGY LABORATORIES
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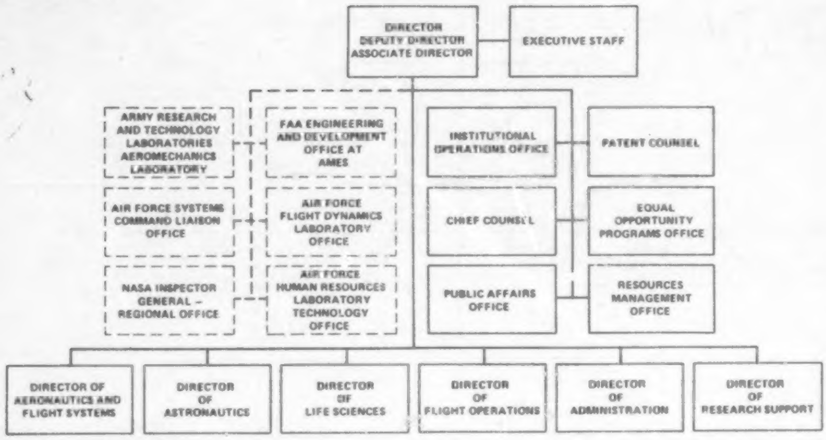
DIRECTOR OF ENERGY
DIRECTOR OF SPACE
DIRECTOR OF SCIENCE AND TECHNOLOGY
DIRECTOR OF ADMINISTRATION
DIRECTOR OF ENGINEERING SERVICES
DIRECTOR OF TECHNICAL SERVICES

Approved:
Date: 9/16/81

ATTACHMENT A
NMI 1107.4 Ch.2

Ames Research Center

September 3, 1981


DIRECTOR
DEPUTY DIRECTOR
ASSOCIATE DIRECTOR
EXECUTIVE STAFF
ARMY RESEARCH AND TECHNOLOGY LABORATORIES AEROMECHANICS LABORATORY
FAA ENGINEERING AND DEVELOPMENT OFFICE AT AMES
INSTITUTIONAL OPERATIONS OFFICE
PATENT COUNSEL
AIR FORCE SYSTEMS COMMAND LIAISON OFFICE
AIR FORCE FLIGHT DYNAMICS LABORATORY OFFICE
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EQUAL OPPORTUNITY PROGRAMS OFFICE
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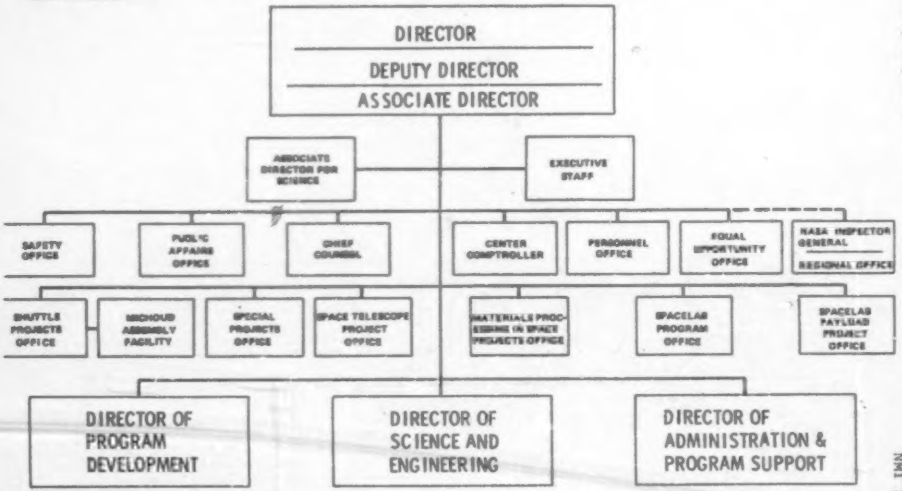
DIRECTOR OF LIFE SCIENCES
DIRECTOR OF FLIGHT OPERATIONS
DIRECTOR OF ADMINISTRATION
DIRECTOR OF RESEARCH SUPPORT

ATTACHMENT A
NMI 1107.5A

Approved September 3, 1981
Date

GEORGE C. MARSHALL SPACE FLIGHT CENTER

February 13, 1981


DIRECTOR
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ASSOCIATE DIRECTOR FOR SCIENCE
EXECUTIVE STAFF
SAFETY OFFICE
PUBLIC AFFAIRS OFFICE
CHIEF COUNSEL
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REGIONAL OFFICE
SHUTTLE PROJECTS OFFICE
MICHOUD ASSEMBLY FACILITY
SPECIAL PROJECTS OFFICE
SPACE TELESCOPE PROJECT OFFICE
MATERIALS PROCESSING IN SPACE PROJECTS OFFICE
SPACELAB PROGRAM OFFICE
SPACELAB PAYLOAD PROJECT OFFICE
DIRECTOR OF PROGRAM DEVELOPMENT
DIRECTOR OF SCIENCE AND ENGINEERING
DIRECTOR OF ADMINISTRATION & PROGRAM SUPPORT

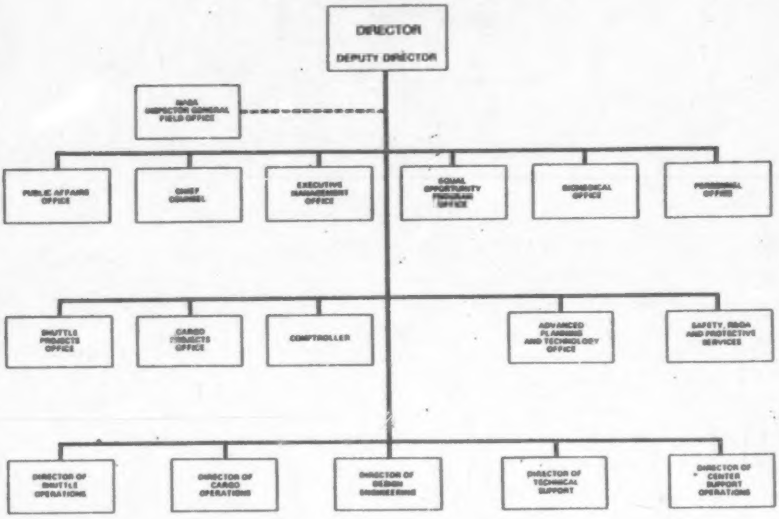
ATTACHMENT A
NMI 1107.6 Ch. 2

APPROVED

DATE FEB 1 3 1981

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JOHN F. KENNEDY SPACE CENTER

April 10, 1980

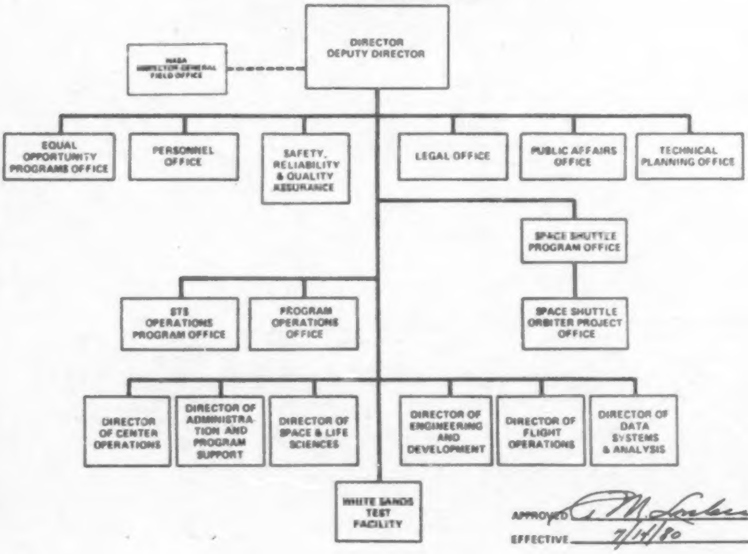

DIRECTOR
DEPUTY DIRECTOR
NASA INSPECTOR GENERAL FIELD OFFICE
PUBLIC AFFAIRS OFFICE
CHIEF COUNSEL
EXECUTIVE MANAGEMENT OFFICE
EQUAL OPPORTUNITY PROGRAM OFFICE
BIOMEDICAL OFFICE
PERSONNEL OFFICE
SHUTTLE PROJECTS OFFICE
CARGO PROJECTS OFFICE
COMPTROLLER
ADVANCED PLANNING AND TECHNOLOGY OFFICE
SAFETY, RQ&A AND PROTECTIVE SERVICES
DIRECTOR OF SHUTTLE OPERATIONS
DIRECTOR OF CARGO OPERATIONS
DIRECTOR OF DESIGN ENGINEERING
DIRECTOR OF TECHNICAL SUPPORT
DIRECTOR OF CENTER SUPPORT OPERATIONS

ATTACHMENT A
NMI 1107.7
Ch. 2

APPROVED A. M. Lovelace
DATE 4/10/80

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS

July 14, 1980


NASA INSPECTOR GENERAL FIELD OFFICE
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PERSONNEL OFFICE
SAFETY, RELIABILITY & QUALITY ASSURANCE
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SPACE SHUTTLE PROGRAM OFFICE
STS OPERATIONS PROGRAM OFFICE
PROGRAM OPERATIONS OFFICE
SPACE SHUTTLE ORBITER PROJECT OFFICE
DIRECTOR OF CENTER OPERATIONS
DIRECTOR OF ADMINISTRATION AND PROGRAM SUPPORT
DIRECTOR OF SPACE & LIFE SCIENCES
DIRECTOR OF ENGINEERING AND DEVELOPMENT
DIRECTOR OF FLIGHT OPERATIONS
DIRECTOR OF DATA SYSTEMS & ANALYSIS
WHITE SANDS TEST FACILITY

APPROVED A. M. Lovelace
EFFECTIVE 7/14/80

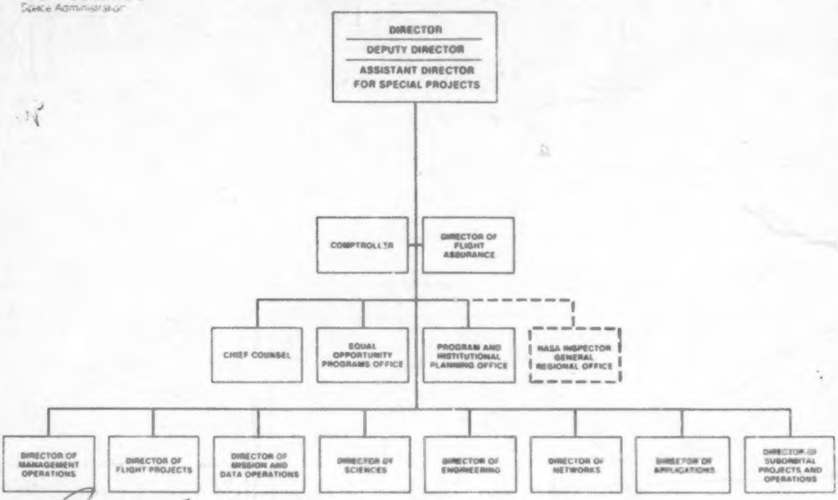
ATTACHMENT A
NMI 1107.9 Ch. 1

NASA
National Aeronautics and
Space Administration

October 2, 1981

ATTACHMENT A
NMI 1107.10A Ch. 1

GODDARD SPACE FLIGHT CENTER


DIRECTOR
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ASSISTANT DIRECTOR FOR SPECIAL PROJECTS
COMPTROLLER
DIRECTOR OF FLIGHT ASSURANCE
CHIEF COUNSEL
EQUAL OPPORTUNITY PROGRAMS OFFICE
PROGRAM AND INSTITUTIONAL PLANNING OFFICE
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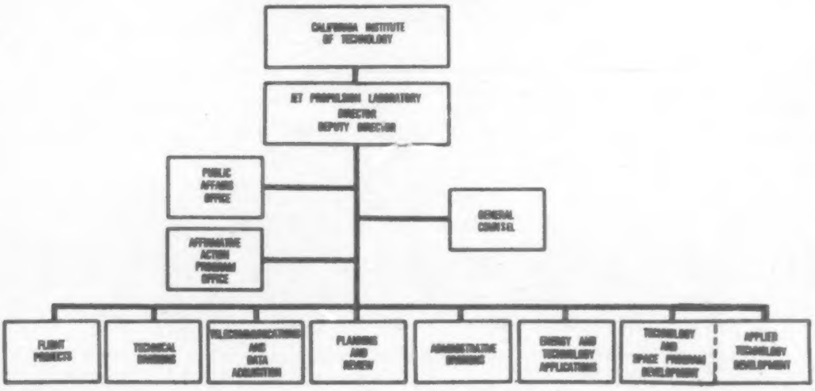
DIRECTOR OF FLIGHT PROJECTS
DIRECTOR OF MISSION AND DATA OPERATIONS
DIRECTOR OF SCIENCES
DIRECTOR OF ENGINEERING
DIRECTOR OF NETWORKS
DIRECTOR OF APPLICATIONS
DIRECTOR OF SUBORBITAL PROJECTS AND OPERATIONS

APPROVED James M. Beggs
DATE 10/2/81

JET PROPULSION LABORATORY
(GOVT.-OWNED, CONTRACTOR-OPERATED)


CALIFORNIA INSTITUTE OF TECHNOLOGY
JET PROPULSION LABORATORY
DIRECTOR
DEPUTY DIRECTOR
PUBLIC AFFAIRS OFFICE
AFFIRMATIVE ACTION PROGRAM OFFICE
GENERAL COUNSEL
FLIGHT PROJECTS
TECHNICAL DIVISIONS
TELECOMMUNICATIONS AND DATA ACQUISITION
PLANNING AND REVIEW
ADMINISTRATIVE DIVISIONS
ENERGY AND TECHNOLOGY APPLICATIONS
TECHNOLOGY AND SPACE PROGRAM DEVELOPMENT
APPLIED TECHNOLOGY DEVELOPMENT

AUGUST 29, 1980

Answer: There are four programs that involve student participation in NASA's activities. They are described below:

NASA/NSTA Shuttle Student Involvement Project: - In September 1980, NASA and the National Science Teachers Association (NSTA) announced the Shuttle Student Involvement Project for secondary schools. The purpose of the project was to stimulate the study of science and and engineering by engaging students in a competition to develop experiments suitable for flight aboard the Space Shuttle.

Over 70,000 students in grades 9 to 12 requested entry materials for the competition. The 10 National Science Teachers Association Regional Directors received 1,500 proposals as entries. Each region selected up to 20 semifinalists who, along with their teacher-advisors, were invited to participate in Shuttle conferences held at NASA field centers. All semifinalist proposals were submitted for national judging held in Washington, D.C. The ten winners of the first year's program were announced in May 1981.

NASA then matched each student with a NASA consultant and a corporate sponsor. The sponsor was asked to assist the student in turning the winning proposal into a flight-ready experiment; pay for development and hardware costs; and pay any necessary student travel. The winners and their teacher-advisors and corporate sponsors attended a national Shuttle conference held at the Kennedy Space Center (KSC) in August.

The first student experiment was flown on STS-3. This experiment, "Insect in Flight Motion Study," was designed by Todd Nelson, an 18 year old senior from Rose Creek, Minnesota. The Avionics Division of Honeywell, Inc. served as the corporate sponsor. The other nine winners from the first year of the project are currently working with their corporate sponsors and will be assigned to upcoming flights as their experiments are completed, and as space on the Shuttle is available.

The second announcement for the Shuttle Student Involvement Program has been made, 2,900 entries were received, and 200 semifinalists were selected. The semifinalists and their teacher-advisors are participating in regional conferences at NASA centers during the months of March and April. Up to 20 national winners will be announced in May 1982.

Urban Community Enrichment Program (UCEP) - In October 1980, NASA and the Federal Aviation Administration jointly sponsored a conference at Howard University called "Learning Through Aviation and Space Education." More than fifty superintendents and other school officials from large urban school districts attended the three-day conference and were exposed to some of the exciting examples of successful aerospace programs which have not only succeeded in exciting students about aerospace careers, but have also served as a catalyst for enhancing the learning process. The Urban Community Enrichment Program, piloted in the District of Columbia public schools in April/May 1981, is a direct outgrowth of that conference.

During FY 1982, programs are being held in Washington, D.C.; Gary, Indiana; Baltimore, Maryland; and Memphis, Tennessee.

Summer High School Apprenticeship Research Program (SHARP) - For the past two years, NASA has conducted a program called SHARP which is designed to establish individual working relationships of students with active researchers who may become mentors when students need advice on college careers. Students participating in this program work closely with their mentors in running experiments, making computations, and collecting data. Many students culminate their summer experience by presenting research papers or by making formal presentations on their work in the laboratry.

In the summer of 1982, 150 students are planning to participate in SHARP 1982 at the various NASA installations around the country.

Graduate Student Researchers Program - The NASA Graduate Student Researchers Program is designed to significantly increase the number of highly trained scientists and engineers in aeronautics, space science, space applications, and space technology to meet the continuing needs of the national aerospace effort.

Each year NASA provides an opportunity for about 40 graduate students in aerospace, science and technology to conduct their thesis research at a NASA center. Selections are made on the basis of a proposal by the student's faculty advisor in a specified research area. Final project assignments are made after an in-depth discussion of the project with the student, faculty advisor, and NASA center project monitor.

Specific research areas are identified each year by the directors of the various NASA centers. These areas are selected especially to provide the students with an opportunity to work on a project of high priority, to use unique NASA equipment and facilities, and to interact with senior NASA research personnel.

Question: How much did NASA receive for services provided by the private sector in FY 1981? How much is estimated for FY 1982? Please provide a detail of amount by services rendered.

Answer: The table below provides the information requested.

	*Reimbursable Orders Received from Non-Federal Government Sources (dollars in millions)	
	FY 1981	FY 1982 Estimate
Expendable Launch Vehicle procurement and launch services	217.1	242.9
Space Transportation Operations	26.4	95.1
Miscellaneous Activities	7.5	3.5
Total	251.1	341.5

*These amounts include orders from foreign government, state and local government, and universities as well as commercial organizations.

Question: What is the NASA policy on doing energy technology activities? How much reimbursable work do you anticipate doing in FY 1982, FY 1983? Is NASA terminating all its own in-house activities?

Answer: In keeping with the Administration's FY 1983 budget request and to minimize the impact of work force reductions on our aeronautics and space roles, NASA will begin to phase out support of terrestrial energy research and development such that by the end of FY 1983, civil service manpower will be applied only to those programs yielding a strong benefit to our traditional aeronautics and space programs, or where continued NASA participation is essential to meeting commitments. We anticipate receiving in FY 1982 approximately $93 million from all the agencies we support in energy R&T. Based on an analysis of the President's FY 1983 budget request, we expect to receive approximately $25 million from these agencies. In FY 1982 and FY 1983, there will be no NASA-funded in-house energy R&T. However, most of the programs that we support on a reimbursable basis involved some NASA in-house R&T.

Question: What is the current status of your launch pricing policy? Do you expect significant increases from your 1977 pricing policy? What are you doing with regard to U.S. policy on financing arrangements?

Answer: In accordance with NASA's published Shuttle Reimbursement Policy, NASA will establish a new price for a standard Shuttle mission flown in 1986. The basis for the new price is currently in preparation for final review and approval by the Administrator. The proposed new price will be significantly higher than the current price to reflect the higher than projected operations costs, but will be structured to be competitive with the Expendable Launch Vehicles, Delta, Atlas/Centaur and Ariane. Financing arrangements have been recognized as an increasingly important element to prospective customers in the overall launch vehicle selection process. We have been instrumental in assisting several foreign customers (Brazil and Colombia) in obtaining financing for their launches from the Export-Import Bank at favorable interest rates. To date we have not been able to identify any similar arrangement for U.S. domestic customers.

Question: What are your views on who should ultimately be responsible for operating the Space Transportation System?

Answer: In the long term I believe it is in the best interests of the government to turn over as much of the operation of the Space Transportation System as possible to either the private sector or some quasi-government/commercial entity. It is not possible today, however, to define that operations management because we are still too early in understanding the Shuttle and its operational implications. In the meantime, I see no alternative to NASA management of the operation in partnership with the DOD. What is important in the near term is to proceed in a direction which will not foreclose eventual transition to an operation having greater involvement of the private sector.

Question: Do you see an erosion of this Nation's science and technology base and, if so, what is NASA's role in alleviating this problem? How do you see NASA maintaining U.S. leadership "science, technology and the applications thereof" as stated in the 1958 space act?

Answer: The condition of the U.S. science and technology base is satisfactory at present. The successful test flights of the Space Shuttle and the spectacular Voyager fly-by of Saturn are two recent demonstrations of NASA's continuing contribution to that base. The Government as a whole, and NASA in particular, must plan carefully and continue to make the best possible use of the funds allocated to its programs. We should accept the competition from Western Europe and Japan in various areas of science and technology as basically healthy, and not try to be dominant in all fields.

NASA maintains U.S. leadership in "science, technology and the application thereof" in several ways. Research from space in X-ray and ultraviolet astronomy, in solar physics, in remote sensing techniques, in communications satellite technology and in other areas has set the standard for the world. The Space Shuttle, Space Telescope, Galileo and Landsat-D, to mention a few examples, continue the same tradition. In the development and application of technology, the Agency will continue its role in promising, high-risk, long-term technology development which the private sector is not prepared to undertake.

Question: In light of the activities of other countries in civil space activities and their future plans, are we adequately addressing the challenges that will be presented to us during the next decade?

Answer: Space is clearly becoming a competitive arena on both an international and commercial basis. The Ariane launch vehicle and the European SPOT programs are clear illustrations of the present and growing competitive nature of space. Although we don't know the detailed future plans of other countries, it's clear that new areas of competition will arise. Speaking only for the civil use of space, I believe we are facing those challenges effectively, although there remain many areas in which decisions have yet to be reached and some changes in legislation may be necessary as we go along.

Questions of Senator Riegle and the Answers Thereto

NASA's FY 1983 Budget Request

Question: It has been widely reported that NASA's FY 1983 request to OMB was $7.6 billion. NASA received only $6.6 billion and that level was granted only after some major appeals were made to the White House. If you had received the $7.6 billion, where would the money have been committed? Would you provide the Committee with your priority listing of programmatic enhancements were NASA to get an additional $100 million, $200 million, etc. up to $1 billion?

Answer: The FY 1983 budget reflects our attempt to preserve a cohesive balance in existing program activities as well as future technology and development capabilities within the overall funding levels. Any consideration of priorities for restoration would have to take into account the general guidelines, the overall program balance, and the impact on future year funding requirements. NASA has not developed a list of priorities for possible restoration. Before allocating any additional funds, we would have to consider the intent of the Congress as expressed in Committee reports, letters, and any attendant legislation, relevant Administration policy, and any problems that surface in the FY 1983 Operating Plan. After considering all of these factors, it might be possible to determine a distribution of additional funds satisfactory to all parties concerned.

Table A shows the difference between the NASA recommendation to OMB and the Congressional Budget.

TECHNOLOGY TRANSFER

Question: The budget for Technology Transfer is eliminated in FY 1983 and that for Technology Utilization is cut in half to $4 million. What is the basis of these actions?

Answer: Although Technology Transfer as a distinct program element is not identified in the FY 1983 budget request, Technology Transfer will be continued as part of the Space Science and Applications Earth and Planetary Exploration Division. The Regional Remote Sensing Applications Program, which was a part of the Technology Transfer program, is now assigned to the Earth and Planetary Exploration Division as a result of the recent NASA reorganization. In addition, FY 1983 is a transitional year in which our emphasis will move from applications of Landsat Multi-spectral (MSS) data to the technique development and testing of new improved Landsat-D Thematic Mapper (TM) data. As a result, we no longer plan to conduct broad-based MSS technology demonstration projects through our Technology Transfer program. Instead, we plan to place more emphasis on the conduct of Experimental Test and Evaluation of emerging new remote sensing techniques through cooperative projects with user organizations. We will also continue to use universities as a mechanism to develop, test, and evaluate new remote sensing techniques with users. We believe that these two activities will make better use of the available resources and continue to involve the user community in improved applications technologies.

In keeping with the need for fiscal restraint, we had to balance the Technology Transfer activities against NASA's overall charter in space research and development. The Technology Transfer activities were adapted to the basic function of test and evaluation of emerging new techniques. We do not believe, however, that this will jeopardize the overall progress made in transferring Landsat capability to the user community. The Technology Transfer program has made significant progress since its initiation in 1976, and, as a result, has sucessfully developed a critical mass of active state users who are beginning to show some independence in their use of Landsat MSS data.

For FY 1983, we are requesting $4 million for Technology Utilization to continue the transfer of NASA developed technology to U.S. industry, the public and other Government agencies. This represents a significant reduction from the current FY 1982 level of $8 million and supports the Administration's policy that the private sector should more actively pursue these efforts. However, while our primary focus will be on the continuation of active publication and technology dissemination activities, we will increase our efforts to acquire larger user contributions from both the private and public sectors. For example, we plan to continue feasibility and planning efforts in technology applications to define public sector applications projects in conjunction with other mission-oriented Federal agencies, with the view toward shifting budgetary responsibility for resultant projects to those user agencies. In addition, we will study the possibility of converting NASA Tech Briefs and other publications to paid subscription.

Question: Your budget contains funds for Landsat-D and-D', and NOAA's budget contains some planning and operational money. The question of who should own and operate an operational remote sensing system and under what terms has not been resolved. What is the current Administration thinking in this area?

Answer: The issue of who should own and operate an operational remote sensing system is currently before the President's Cabinet Council. An Administration position is expected shortly.

FY 1982 Operating Plan

Question: The FY 1982 Operating Plan proposes to reprogram money for two projects--one to demonstrate the capability of the Shuttle to retrieve and repair a payload (the Solar Maximum Retrieval Mission) and a second to develop a lighter solid rocket booster (using filament wound casing)--thereby increasing the Shuttle thrust capability. The timing of the first project is largely in response to DOD requirements. In addition, we hear public statements that DOD may wind up running the Shuttle.

Furthermore, in the non-Shuttle area, the only aeronautical systems technology programs approved were those of importance to the military, while programs of commercial and economic importance were disallowed.

Beyond the assurances in your statement that the Administration is committed to an independent NASA, how do you respond to the perception in many people's mind that the DOD is driving NASA programs? Is the military paying its fair share?

Answer: NASA is charged with performing research and technology development in aeronautics and space, in support of national objectives. Much of the work provides a common technology base in the various disciplines, applicable to users across the board. In general, NASA develops basic technology, and the individual users draw upon that technology to design and develop their particular products. NASA has always had a close working relationship with DOD, with mutually beneficial arrangements of fair-share funding or quid pro quo.

The extent to which NASA programs support the requirements of the civil and/or military users at any given time is a reflection of national policy. In the examples cited, it should be noted that satellite retrieval capability and Shuttle performance augmentation have long been recognized as legitimate objectives of the space transportation system that will benefit civil users as well as military. The realignment of activities in the aeronautics program reflects a policy decision that Government-funded effort should focus on more fundamental research and technology development, while specific development of the technology in commercially viable applications should be financed by the private sector. While there is clearly greater attention in the budget to NASA activities with national security implications, it is our position that all items in the NASA budget are properly funded by the Agency.

30/20 GHz

Question: It is my understanding that there is little doubt that the United States will need to use the new 30/20 GHz frequency region for communications satellites. The Japanese already have such a demonstration satellite in orbit and plan to have a third generation version up in 1987. Many believe that U.S. leadership is at stake in yet another industrial sector. And still, in spite of this strong competition, NASA is eliminating the 30/20 GHz demonstration program. What is the basis for this decision, and do you really believe that industry will pick the program up? Are there less costly approaches the United States could pursue (e.g., either cost sharing or a more modest demonstration) and still stay competitive?

Answer: The decision not to pursue a 30/20 GHz demonstration program is consistent with the Administration's policy not to spend Federal funds on large demonstration missions where it can reasonably be expected that the commercial sector would be the principal beneficiary and, thus, should be expected to assume the responsibility. Whether or not the commercial sector will pick up such a demonstration effort remains to be seen.

We are currently examining the feasibility of restructuring our communications program to emphasize the high risk technology development required to ensure continued U.S. preeminence in the field of satellite communications. The changes being considered will improve the program by broadening its applicability to NASA, other Government agencies, and U.S. industry programs while adhering to Administration guidelines. By broadening the applicability, we will expand experiment and cost sharing opportunities to include universities, other Government agencies, and other nations and consortia, as well as U.S. industry. We hope to reduce the cost to the Government by this process.

National Aeronautics and Space Administration

Congressional Budget Request/OMB Budget Request

	FY 1983 Budget Request to Congress	△	FY 1983 Budget Request to OMB
Space Shuttle	1718.0	+190.0	1908.0
Space Flight Operations	1707.0	+162.5	1869.5
ELV	42.8	—	42.8
Physics & Astronomy	471.7	+80.6	552.3
Planetary	154.6	+49.8	204.4
Life Sciences	55.7	+2.5	58.2
Space Applications	316.3	+127.0	443.3
Technology Utilization	4.0	+7.7	11.7
Aeronautical Research & Technology	232.0	+139.0	371.0
Space Research & Technology	123.0	+36.0	159.0
Tracking and Data Analysis	508.9	+109.7	618.6
Total Research & Development	5334.0	+904.8	6238.8
CofF	100.0	+64.8	164.8
R&PM	1178.9	+34.0	1212.9
Total NASA	6612.9	+1003.6	7616.5

TABLE A

Senator SCHMITT. The hearing is recessed.

[Whereupon, at 12:20 p.m., the hearing was adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1983

THURSDAY, FEBRUARY 25, 1982

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met, at 9:45 a.m., in room 357, of the Russell Senate Office Building, Hon. Harrison H. Schmitt (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. The hearing will come to order.

The last time I was in this room, I was vice chairman of the Ethics Committee. You all haven't misbehaved, I hope, since we last met.

I can't imagine why they would ever design a hearing room like this, unless Senators were much bigger in the old days than they are today. Certainly, they couldn't have been more pompous.

The past year has produced remarkable achievements from NASA's space transportation system, which is the subject of our hearing today, achievements which we have come to expect as the norm from an agency which has put both a man on the Moon and a miniature biochemistry laboratory on Mars, and which has sent pictures back from the outer planets that were both breathtaking in their detail and scientifically extraordinary in their content.

The advent of mankind's move into space has surely begun in earnest with the successful relaunch, and I italicize "relaunch," of the Space Shuttle Columbia. It is with a large measure of national pride that we can see reflected in the 1983 NASA proposed budget for the space transportation system the transition from the development phase to the operational phase. It is critical, however, not to allow our success to divert attention from continued careful management of a very expensive program, a program which, if things went wrong, could easily assimulate large portions of the budgets of other important areas of NASA and national responsibility, such as aeronautics, and space technology, and space science, and application.

In fact, if things went wrong, we might very well be diverted from developing this essential national capability.

A major question that naturally arises during the transition into an operational status for the Shuttle is who should be responsible for the permanent management of the space transportation system? If commercial users are to play a predominant role in the use of the Shuttle, then the business community must be sufficiently involved in any operational scenario to be convinced that their interests are being served. Whether a government, or private corporation, or a government agency is to be involved is as yet an open question. More careful and creative thought is needed before conclusions are reached.

Added to this uncertainty, of course, is just what magnitude will the long-term defense requirements be and how should a defense-dedicated fleet, if there is to be one, be operated in space?

If the Shuttle is to be fully exploited as the national resource that I believe it is, NASA must develop and firmly hold the support of its customers in both the commercial and in the national defense arenas. The joint venture agreements between NASA and McDonnell Douglas and GTI are hopeful signs that the possibilities for commercial exploitation of the unique environment of space are beginning to be recognized by industry.

However, aggressive marketing is needed before the Shuttle will be, in any sense, self-supporting. It is amazing how few people in the business community and elsewhere understand just what the unique resources are in this new environment, accessible environment, of space. The weightlessness, where convection is no longer a significant physical process, where high-vacuum and high-pumping rates offers whole new opportunities for materials development and where there is a unique view of the Earth, the Sun, and the stars, beyond anything previously accessible to mankind.

While the Shuttle is of potentially great value to the national security of the United States, and while the various armed services have each defined their needs for launch services as they now see them to support their existing missions, it is clear that the civilians are still leading the way in pushing out the frontiers of space, and furthermore, are bearing the cost of expanding our national capabilities.

There are some who have not yet recognized that the Shuttle is not just another dumb booster. The use of the Shuttle as a means of repairing damaged satellites, providing services to ongoing civilian, as well defense missions, and in creating whole new concepts of how we serve mankind, both in the production of new goods and services, and in the preservation of peace, has great potential for reducing the cost of being in space.

Further, the presence of man in space is an advantage that I fear is not being fully recognized, particularly by the Department of Defense. Programs which promote the usefulness of the Shuttle for extension of the life of an expensive satellite in a cost effective way should be supported by those responsible for our national security, to whose benefit these activities will naturally accrue; 1982 portends to be as exciting as 1981 in terms of what is in store for the Space Shuttle. As we applaud our technical accomplishments to date, it is clear that we must not lose sight of the future of the space program. Man's conquest of space has been, and can only be, accomplished by the careful laying of the foundation upon which the ultimate structure is set. The Shuttle is the cornerstone to success, but it is no guarantee of it. It is merely a new technology. It is not a policy.

If the United States is not to relinquish preeminence in space to other nations, it must vigorously and carefully develop options and strategies for a permanent presence in this new ocean.

The momentum generated by our current success must not be allowed to diminish. We must not rest on our laurels, but see the conversion of the Shuttle program from development to operation as an opportunity for vigorous new beginnings.

This morning, we have with us as witnesses to discuss the transportation system and its operational transition, Maj. Gen. James A. Abrahamson and Dr. Stanley T. Weiss. We would like each of you to present your testimony. We will give you 10 minutes. If that is not sufficient—each 10 minutes—if that is not sufficient, your entire testimony will be included in the record as if presented, and we'll go to the questions.

General Abrahamson?

STATEMENTS OF MAJ. GEN. JAMES A. ABRAHAMSON, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE TRANSPORTATION SYSTEMS, ACCOMPANIED BY MICHAEL WEEKS, DEPUTY ASSOCIATE ADMINISTRATOR; AND DR. STANLEY T. WEISS, ASSOCIATE ADMINISTRATOR, OFFICE OF TRANSPORTATION OPERATIONS, ACCOMPANIED BY JOSEPH A. KRATOVIL, DIRECTOR, RESOURCES MANAGEMENT, NASA

General **Abrahamson**. Mr. Chairman, it's a pleasure again to be before this subcommittee that has such a reputation of leadership in the space business. I take to heart the challenge that you have laid out for us in your opening statement and I assure you that the entire agency, and I recognize the challenge that you have laid out in the commercial and the civilian scientific and in the security interests.

It is my personal belief that we are limited more by our imagination at this point in time than by budgets or other issues. That doesn't mean the budgets are not important. Therefore, I am delighted to present my testimony in support of our fiscal year 1983 budget request. I would like to offer my statement for the record. I do have a short presentation and I will stick strictly to your 10 minutes.

Senator **Schmitt**. Please proceed.

[Slides shown.]

General **Abrahamson**. I am very pleased to offer this picture of Columbia on the pad [figure 1]. You'll notice we're not painting the external tank any more. We are now approximately 4 days ahead of schedule for the launch on March 22, and everything is going extremely well.

Senator **Schmitt**. Will you bring that schedule forward? Will you launch early, if you can?

General **Abrahamson**. No, sir; I don't intend to. I think the important point now is that we have a stable approach to that launch, a well-planned one and that we do not deviate from procedures.

Senator **Schmitt**. I agree.

General **Abrahamson**. Thank you. Given your special background, I appreciate that.

Senator SCHMITT. Well, my special background now includes trying to make my own schedule jibe with that launch.

General ABRAHAMSON. I am also pleased, given your remark of last Tuesday, to see that we did not inadvertently misspell "space" on this slide.

Senator SCHMITT. Well, you've been around NASA long enough.

General ABRAHAMSON. This short presentation is intended to provide a framework for our budget discussion. I thought it would be useful to point out the prioritization we used as we reviewed the program. These were applied in our budgeting process, both in the way in which we reviewed our fiscal year 1982 operating plan and in the way we looked at our fiscal year 1983 budget itself.

If you'll notice, first and foremost is a safe and successful mission [figure 2]. There is no question in any of our minds that we must conduct each mission safely and we must maintain the schedule for each mission, and that, of course, is our first program and budget priority. However, you'll see, in the second priority, a change. In the past, we have maintained the completion of the development program as the second budget priority. Clearly, we have allocated a major portion of our funds for that. However, I have moved maintaining the operational launch schedule to the second priority, and third, to reduce operational costs. Then, the fourth priority, we will proceed with some of the less critical aspects of the development program. Although it is a lower priority, it is clearly very important to maintain the orbiter production schedule. Once established, maintaining the schedule is what will then determine the most efficient—from a cost viewpoint—way to produce these orbiters.

We also have to maintain our facilities which is the last item—I'm sorry to say that exhancing capabilities has to be last in this particular order, but this goes to your point that we must challenge the system with the way we use the Space Shuttle. I do have money in for those purposes, and we are working on efforts to make people realize that the Space Shuttle is not a truck, but a new capability.

Figure 3 is our schedule for the launches. Our firm schedule for March 22 is right here [indicating]. Our next launch has already moved up slightly. It was scheduled for July 7 and then we were looking to the July 2. Now, we are working for June 27. I think that date will remain stable, if we return from the third launch in good condition with no untoward surprises. After that, we're looking to a November launch for our first operational mission.

Senator SCHMITT. Is the main reason that you are moving ahead of schedule in the development phase because of the reduced requirements for refurbishment of each vehicle.

General ABRAHAMSON. That is a factor. However, when the original schedule was laid out, we did have those modifications worked in. I think the important thing is that we are learning and we are learning very effectively. So we're moving down a learning curve.

The orbiter delivery schedule [figure 4] is now reasonably stable. However, I would like to point out that there is risk in this schedule. OV-099 is running slightly behind, but we believe that we're still aiming for the June delivery. It then goes to KSC for a series of tests and checkouts. Later, it joins up with the engines and the OMS pods and is made ready for the STS-6 launch, which is presently scheduled for January 1983. That's our first TDRSS launch, which is important not only to NASA, but also the Department of Defense. After SIS–S, Orbiter 102 goes back for modification. Orbiter 103 is slightly behind schedule, but not badly. For Orbiter 104, we are still aiming for a December 1984 delivery. We have allocated our resources very tightly to maintain these schedules, but I believe that we have an appropriate allocation.

We have also undertaken a series of management initiatives [figure 5]. One of these is a revised approach to our budgeting process. I mentioned earlier that in 1979, I had the pleasure to participate in a committee to review the Shuttle management. I guess the lesson for me is that you'd better be careful when you offer free advice because you might have to live with it. And indeed, I am now having to live with that free advice. One of the important items was that we should insure that there are some reserve, at the NASA centers so that the people who are managing the program on a day-to-day basis do know what resources they have to work with. We have done that for fiscal year 1982 and fiscal year 1983. We are, as an agency, moving to put very strong operational emphasis into the program and, of course, error-free operations as a goal. This is an incredibly complicated vehicle, but it is error-free operations that is enabling us to move down this learning curve.

Cost-incentive contracting is also a way in which we can insure that the companies are rewarded when they bring down the costs of each of the various operations. We have three contracts now that we are in the process of converting from award-fee to incentive-fee arrangement. One of those is the external tank, and that's in negotiation with Martin. One is the SRB, and that is in negotiation with Thiokol. The third is the filament-wound case RFP which we released Monday. It is for a cost-incentive contract in the development phase with a not-to-exceed price for the initial production portion. We are also working on manufacturing modernization initiatives. There was a strong program in place before my arrival, and I'm pleased that we're able to expand on it. We're also working on an agencywide initiative for productivity. That effort is underway and I'm using some of the initiatives that we used on the F–16, as well as other industrial initiatives to try to expand these activities.

In the framework of the budget [figure 6], there are some accounting and concept changes. D.D.T. & E., of course, ends here in fiscal year 1982. That doesn't mean that the development effort is really over. Actually, there is about $200 million worth of money that could be classified either as development or as production. We have arbitrarily cut it after fiscal year 1982, in accordance with the plan which was presented to Congress a year ago. That effort will now go out in the future. An example of continuing development is the life certification testing of the engines. It will be in the production budget in the future.

There is one other change that should be noted and this is the DTMS, where we have changed the concept from DTMS. DTMS, of course, was our development test and mission support activity. We're now going into a different concept called engineering and technical base, where the budget itself contains funding for a basic level of support. That amounts to $82.4 million in fiscal year 1983, to provide constancy for our institutional technical base. However, the programs on an industrial funding basis will then look ahead and will have to pay for added support or special requirements. This is an attempt to get them all to consider marginal requirements and to minimize those marginal requirements.

The other key point is that our overall budget is some $3.4 billion [figure 7]. A change in the institutional management of NASA has put the four centers listed under my control for the research and program management [R. & P.M.] or the manpower, administrative, and travel costs associated with those centers. They are only up slightly from fiscal year 1982 which reflects inflation primarily. I also have responsibility [figure 8] now to insure that we have fully coordinated construction of facilities [COFF], with the rest of the program. The largest chunk of our $37 million is at MAF, and that is really to insure that we have the facility to produce those tanks, down the learning curve to the costs that we're after. That's going to be a very great challenge, to bring them down into the $10 million range. Right now, they're about $37 million.

If I may summarize, then, STS-5 begins our operational era [figure 9]. The budget reflects a schedule for 32 flights in total through fiscal year 1985. We're aiming, of course, for a 24 per year capability by 1988. That does not mean that we really think that 24 per year is the limit of this system. This is a planning base which can be used consistently across the agency. It does reflect the present manifest that Dr. Weiss will talk about. The key point is that as we see demand increase, then we'll have to look into that. I fully expect that it will increase rather than decrease. Orbiter deliveries, within some few weeks of leeway, are basically on schedule.

I'm pleased to point out that our first of four engine certification cycles at the full-power level of 109 percent has been completed. We have three more cycles to go on the engine which will be completed early in 1983. We expect the filament-wound case to be ready in 1985 to support the first DOD launch out of Vandenberg Air Force Base. We expect to have the high-performance motor for the solid rocket booster ready in 1983. That will give us around 2,000 pounds of increased payload per performance. The lightweight external tank will be delivered in September 1982 and that will support STS-6. We are also working on the manned maneuvering unit, which will be important for the solar maximum repair mission. KSC facilities are essentially on schedule, and we are looking for that operational date at Vandenberg in 1985. And we will complete our second KSC launch pad in 1986.

This is a brief summary of the budget and I am now ready for any questions, sir.

Senator SCHMITT. Why don't we take Dr. Weiss' testimony and then, if necessary, both of you can contribute to the answers.

General ABRAHAMSON. Fine.

Dr. WEISS. Thank you, Mr. Chairman. I am very pleased to present the activities of the Office of Space Transportation Operations and its fiscal year 1983 budget request. With your approval, I would like to submit my full testimony for the record.

Senator SCHMITT. It will be incorporated.

Dr. WEISS. Thank you. I appreciate the framework that you have established for this hearing and I would like to proceed by illustrating how our request for the space transportation operations program falls within that framework and substantiates our program, but within the fiscal constraints of the President's economic program.

The responsibilities of my office are to manage and coordinate the U.S. civil launch capabilities and to cooperate with the Department of Defense in providing launch services for national defense missions. The Office of Space Transportation Operations is responsible for the formulation of policies for users of the national space transportation system which will consist of the operational fleet of Space Shuttles and a stable of proven expendable launch vehicles. The policies include shuttle and expendable launch vehicle pricing, development of launch service agreements—those are our contracts with the users—and the use and pricing of the Spacelab, as well as our small self-contained payloads; that is, the getaway special program. In addition, we are responsible for the marketing and scheduling of the launch services of these space transportation capabilities. We're also the NASA office responsible for the Spacelab development performed by the European Space Agency and for its operation as an element of the space transportation system.

Consistent with these responsibilities, our attempts are to maintain the U.S. position as a world leader in space activities, with the objective of providing useful space support services for the Department of Defense, other Government agencies, industrial and scientific users. To conduct the 28 operational Space Shuttle missions we now have programed through fiscal year 1985, the maintenance of a Space Shuttle price per flight which recovers reasonable cost to the Government while remaining competitive. Competitive is a term here that applies not only to the new competition we're seeing from the Ariane, but also to the expendable launch vehicles that have provided services in the past as well as to achieving the maximum benefits from the U.S. investment in the Shuttle.

Looking at our recent activities, our commercial business operations for the office grew considerably during the past year as the national space transportation system moved toward operations of a truly mixed fleet. In fact, we're utilizing the expendable launch vehicles and Shuttle capabilities and availability in package offerings to communications satellite users. For example, we recently proposed a combination of a Delta launch in early 1985 and a Shuttle launch in 1986, to satisfy the schedule requirements for the Brazilian communications satellite system.

Our 1981 accomplishments can be summarized briefly. We had 11 successful expendable launch vehicle launches. In addition, we accepted delivery of the first Spacelab flight unit in December and celebrated its arrival at Kennedy Space Center with a ceremony just a few weeks ago. At that time, Vice President Bush expressed the administration's strong support for our space program. We had the first operational mission of a Spacelab instrument pallet on the Shuttle. It was an engineering pallet which served as the base support system for the OSTA-1 payload on STS-2. On STS-3, we'll have another such system supporting scientific missions. We have also signed bookings for 41 additional reimbursable payloads and signed a launch service agreement for the Shuttle and three for the expendable launch vehicles, as well as having several others in the wings ready for signature in the first quarter of calendar 1982.

In addition, very important to us was the signing of 28 new, small, self-contained payload bookings and launch service agreements, as well as the start of our production activities to provide expendable hardware for the Space Shuttle with 10 external tanks and four sets of solid rocket boosters now in process. In addition to our planned activities for fiscal year 1982, which concentrated on preparing for the start of operational Shuttle missions this fall, we'll include procurement of external tanks and solid rocket boosters, delivery of the additional two-stage IUS's for the tracking and data relay satellite system, upgrading the mission control center, and development and initial testing of equipment such as the self-contained payload containers which will fly on the OFT test vehicles. Spacelab 1 is also proceeding toward a September, 1983 launch and we're supporting that process. Meanwhile, our launch services activity continues with 13 expendable launches, using 7 Deltas, 3 Atlas-Centaurs, 1 Atlas-F, and 2 Scouts in this next year.

Since 1983 is the start of operational commercial use of the Shuttle, I would like to review our near-term schedule for the space transportation fleet activity over the next 5 years. [figure 1]. This is really a fleet usage chart emphasizing the mixed character of our capabilities. You'll note that with the exception of five tracking and data relay satellite launches under NASA's sponsorship, the commercial and foreign usage of Shuttle is 35 percent of the expected traffic. This not only emphasizes the growth of the satellite communication business, but also the demand that has given rise to competition for this market. It has also extended the continued use of expendable launch vehicles and we are assuring the continuation of that expendable fleet to meet demand not yet fillable by the Shuttle. The body of customers is broad, both for the United States and for foreign communication satellites. So that the market case for competition is clear.

The French-managed Arianespace is actively marketing launch services with the European Space Agency-developed Ariane launch vehicle, and Monsieur d'Allest, I'm sure, will describe that more adequately than I could. NASA, on the other hand, is responding to the Ariane by offering the Delta Shuttle launch service packages which I described earlier. By holding discussions with the Export-Import Bank [Exim] concerning financing arrangements for payload users which have been rather favorably organized, we're developing alternative pricing strategies for the Shuttle and expendable launch vehicles—clearly striving to keep our cost per flight for Shuttle usage down as an important key to competitive pricing capabilities.

The competitive advantages of the Shuttle over any expendable launch vehicle are related to the special capabilities that are intrinsic in the design of the Space Shuttle. The milestones that will provide demonstration of these so that we will be responsive both to user requirements now and, hopefully, stimulating potential users, are very, very important to us [figure 2].

Of particular importance is the first payload deployment we'll have with the launch of the two commercial communications satellites on the fifth flight which is our first operational flight in fall of this year. Two flights later, that is the seventh Shuttle launch, the payload will be the European-deployable and retrievable system called SPAS, and that will be part of a venture that we have been working on with the Europeans for a good number of years. It will provide a very valuable demonstration, both to the United States and for the subsequent use of that system.

At the same time, in between those two launches will be the first launch of the Tracking and Data Relay Satellite, which has the further importance of being the first demonstration of the IUS on the Shuttle. In September 1983, the first Spacelab will be launched. In the subsequent year, we'll have the second Spacelab, and third and fourth through 1985.

To further demonstrate the capability of retrieving and servicing, we hope to have the Solar Maximum Mission retrieval, which will give us the capability of demonstrating that special capability in the near-term; that is, in 1983.

Our fiscal year 1983 plan is a very active and ambitious one [3]. It particularly deals with establishing the Space Shuttle as the major aspect of our space transportation system. Efforts in Shuttle operations cover the launch of five operational Shuttle flights, the procurement of the hardware necessary to support that, and the provisioning of spares, ground equipment, and cargo operations to support those five and future flights. In adddition, our upper stage operations include procurement of IUS vehicles for TDRS, as well as two additional two-stage vehicles for Galileo and the International Solar Polar Mission (ISPM) launches. Payload support operations will cover about 33 NASA payloads that will be launched through fiscal year 1986, the major ones being the TDRS, Galileo, Space Telescope, and the Spacelabs.

Spacelab, of course, is heading toward that first launch, although half of the funds in that line item are applied to procurement of the second unit, for which we are contractually obligated and which will be used for Spacelab 2. Funds for expendable launch vehicles are solely for NASA missions, with the bulk of this $250 million plus activity being fully reimbursed by the users currently.

I believe we're planning a very ambitious program for 1983 with the initiation of operationsl Space Shuttle missions and the first flight of the Spacelab and continuation of ELV operations. We're looking forward to achieving the goals that I noted earlier, and looking forward also to receive the auspice of this subcommittee in those achievements. Thank you.

Senator SCHMITT. General Abrahamson, how comfortable are you with the $72 million allocated for fiscal year 1983 for changes/systems upgrading in light of the unexpected uses of $264 million in fiscal year 1982, with three flights left in 1982 and five flights scheduled in 1983?

General ABRAHAMSON. Actually, the changes and systems upgrading budget line, as it's indicated there, is provided principally to fund increased capabilities and upgradings. The key to your question is not just that line by itself, but the combination of that line and reserves that are contained in the basic program estimates. We have distributed about half of the total reserves for fiscal year 1983 to the centers already. So, the centers know that their current reauirements are met.

You asked how comfortable I am. I always appreciate a little more, but in terms of the budget balance, I think that it is appropriate.

Senator SCHMITT. What is the tangible evidence that you will require less in 1983 than you've used in 1982?

General ABRAHAMSON. I think perhaps the best way to answer that is with some specific numbers on changes. If I may, I'd like to provide that for the record.

[The following information was subsequently received for the record:]

In the fiscal year 1982 Operating Plan submitted to Congress in January 1982, $264 million was allocated to DDT&E and production from the Changes and Systems Upgrading budget. Of this total, $158 million was allocated to DDT&E and $106 million to production.

The major requirements for the DDT&E increase were the modification and changes to external tank and solid rocket booster hardware and the launch facilities at KSC due to the STS-1 and STS-2 experience; launch processing support at KSC for critical path activities; increased support and data reduction activities; and completion of life qualification of orbiter subsystems. The allocation to production was due primarily to the significant increase in orbiter flight spares unit costs; the orbiter spares and crew equipment quantity requirements; and the need to accelerate main engine critical components and production engine deliveries.

The Changes and Systems Upgrading budget request for fiscal year 1983 is $72.5 million. The allowance is significantly less than the $264 million allocated to the Shuttle DDT&E and production in fiscal year 1982, but in consideration of the status of the program, the reduced amount represents a reasonable level for fiscal year 1983. This is based on three factors: (1) the orbital flight test program will be completed in fiscal year 1982, and the number of changes during the remaining development flight testing are expected to be limited; (2) major increase in funding requirements for orbiter flight spares and crew equipment, systems integration activities, and production rate tooling, have already been incorporated into the production estimates; and, (3) we expect the rate of technical changes to continue to decrease to levels which can be funded within the contingency allowances included within the Shuttle Production budget estimates. This budget posture in turn permits us to plan the use of the Changes and Systems Upgrading budget allowance for future changes, to identify redesigns to increase system performance and reliability, to reduce turnaround times between missions, and for modifications of hardware to achieve improved operating efficiencies. In consideration of the overall Agency budget request for fiscal year 1983, we believe the $72.5 million is an appropriate and reasonable level.

General ABRAHAMSON. We are approving some changes. For example, I just recently approved an important change to the external tank. This is a manufacturing kind of improvement, where we remove some external line and move the GOX vent valve to the side so that we can get better launch pad processing; thereby, reducing operational costs. However, that's something that goes in the opposite direction in the short run.

The fiscal year 1983 impact of that will be about $9 million.

Senator SCHMITT. Nine?

General ABRAHAMSON. Yes, sir, Where we exceed that $72 million, I'll have to dip into the reserves. But, I would like to provide for the record some extrapolation, as you indicated.

Senator SCHMITT. What do you consider the level of your current reserves or your 1983 reserves?

General ABRAHAMSON. The fiscal year 1983 reserves are about 5 percent of the total program, that 5 percent is distributed between mine and Dr. Weiss' portion of the budget. If I look at the overall balance between operations and the portion of the budget that I control, Dr. Weiss' portion of that 5 percent is very tight.

Maybe you would like to add a comment about that, Stan.

Dr. WEISS. I think you said it. It's a tight program that we have organized. Fiscal year 1982 certainly is even more stringent. But, our fiscal year 1983 plan looks like it's adequate to meet our expectations, short of any trauma.

Senator SCHMITT. Doctor, what have you learned so far in your work on the Spacelab? Does it look like it's going to be a comparable system to what NASA is used to flying in terms of the cost of bringing up the operational status, and maintainability?

Dr. WEISS. We've been very pleased, frankly, with the quality of the system, both in terms of the mechanical aspects and the control systems that supply data, communications, what I call the "heat, light, and power aspects" of thermal control, et cetera. The initial checkouts with the engineering model went more smoothly than we had anticipated, and the engineering model is the only one that we have powered up to date. With the receipt of the first flight article, the handling equipment has worked extremely well. I would say the only area where we would look for concern, which requires special attention on our part, is the fact that we don't have a full Spacelab mockup at JSC which would work on an integrated basis with the other simulations.

So what we're doing to resolve the communications and data interactions is to establish a direct link between the Marshall Space Flight Center, where we do have training capabilities, and at the Johnson Space Center, where the Shuttle simulation for the pilot and commander exists and down at Kennedy, where the actual equipment lies. So we will have a link for all of those which will permit at least a very strong simulation of operations.

Senator SCHMITT. Well, I have previously expressed my concern over your inability to run a fully integrated simulated sequence for payloads, including Spacelab. I still have that concern. I think the value was well demonstrated in the previous program. I am very disappointed that NASA was unable to see their way clear to create that capability for the Space Shuttle.

Dr. WEISS. We appreciate that concern; but we think that this data link arrangement will certainly improve our situation.

Senator SCHMITT. I hope that you don't appreciate it even more when you start to fly them.

General Abrahamson, how committed is the agency to maintaining the Orbiter 104 delivery schedule?

General ABRAHAMSON. As I indicated in that priority listing, we think it's very important. Therefore, we have allocated the money that we think will do that job. I'm not sure how to measure commitment—it is a personal commitment of mine to maintain that schedule.

Senator SCHMITT. Well, does your personal commitment match with the resources allocated in the budget?

General ABRAHAMSON. In a very tight way, yes, sir.

Senator SCHMITT. Are you going to be able to do anything to maintain the capability to acquire the long lead items for the 105?

General ABRAHAMSON. It is extremely important that we try to keep our subcontractor base, especially, in a consistent operating mode, otherwise, the prices will, in fact, go up in a dramatic way. In my judgment, we may not even be able to maintain the same level of confidence in any subcontractor items.

Senator SCHMITT. Has the Air Force offered any assistance in doing that?

General ABRAHAMSON. Not at this point; we have not asked. We have looked at that as our responsibility. That is part of the blockbuy study ——

Senator SCHMITT. I'm sorry, I forgot that Secretary Weinberger said that Shuttle is not a high priority for the Department of Defense.

What do you expect to be the total run-out cost for the filament wound case?

General ABRAHAMSON. We're expecting in fiscal year 1983 dollars that will be on the order of $250 million. As you recognize, these are in-house Government estimates at this time, and that $250 million includes the development cost. It also includes buying three sets for operational use as well as systems integration costs. The first one, is the one that we talked about being used at Vandenberg. The other two will be available for future missions.

Senator SCHMITT. What was the total development cost of the solid rocket boosters up to this stage?

General ABRAHAMSON. Let's say——

Senator SCHMITT. That's development, not procurement.

General ABRAHAMSON. I believe it is $582 million; but, I'd like to ask Mr. Weeks to comment just about the content of the number.

Mr. WEEKS. The $582 million will have been spent when the total development is complete, which won't be for about a year. It includes the purchase of six flight sets of reusable hardware which is, of course, 12 solid booster motors; and the development and initial tooling.

Senator SCHMITT. What has been the experience in refurbishment so far? Is that yours or Dr. Weiss?

General ABRAHAMSON. The most disappointing thing in the STS-1 and STS-2 flights was that the aft skirt of the SRB did sustain some damage. We now have a design fixed for that problem.

Senator SCHMITT. That's impact damage?

General ABRAHAMSON. Yes, sir, that is impact damage, as it struck the water along with some reentry heating damage. Some fixes have been designed. The first of these is being built into the next sets on STS-3. We'll see if these fixes are valid. The primary fixes involve vertical stiffners which go between the three main rings to strengthen the aft skirt and connections to the large hydraulic units that control the thrust vector control system.

Senator SCHMITT. Will the filament wound case be reusable?

General ABRAHAMSON. That is an objective, clearly. In the RFP that we have released, we've made that objective very clear. We do intend that the design should be such that it will be reusable. However, in their bids, we are not asking each of the contractors to propose that the full qualification program for that reusability be achieved by the first flight using the filament wound cases. We think that a lower cost way to determine exactly how reusable it is to fly it once, bring it back and then do some testing on it. We believe that may determine what the final program will be. In the

RFP, we're asking, for approaches for qualifying reusability. We have made a point in the source selection criteria that we will evaluate the reusability of the design in the competition. It's clearly our objective that it should be reusable. In fact, we won't be able to determine the economic trade-off between the filament wound case and the steel cases until we can reasonably demonstrate that it is reusable and until we can get some reasonable number of reuses.

Senator **Schmitt**. Would it be appropriate to ask at least in the RFP for their estimate of what it would cost to certify reusability prior to the first flight?

General **Abrahamson**. What we have asked for is their plan for how they would approach that reusability and, yes, that should include cost. Frankly, I have to go back now and insure that I'm accurate in this statement. But we have asked for their plans for achieving the reusable objectives.

Senator **Schmitt**. Supply that for the record, would you?

General **Abrahamson**. Yes, sir, I will.

[The following information was subsequently received for the record:]

In the Request for Proposals (RFP) on the FWC, reusability is addressed several times. Under the section on FWC Design a statement is made "that it is NASA's objective to achieve reusability of the FWC." In the Engineering section proposers are requested to "specifically address plans for the evaluation of the feasibility and cost effectiveness of refurbishing and reusing the composite materials portion of the FWC." The importance of reusability is highlighted further in the source selection criteria as follows:

"CRITERION 1—DESIGN, ANALYSIS AND VERIFICATION

Evaluated under this criterion will be the proposer's demonstrated understanding and compliance with RFP requirements and proposed implementation of the design, analysis, and verification requirements; including but not limited to such items as state-of-the-art design, axial elongation and its dispersions, the early verification of the design to assure schedule compliance, and the proposer's plan for the timely evaluation of the feasibility and cost effectiveness of refurbishing and reusing the composite materials portion of the FWC."

Senator **Schmitt**. It seems at least that it should give you some insight into the trade-off between reusability determination after first flight and before.

General **Abrahamson**. Actually, a great deal of it will depend——

Senator **Schmitt**. I, personally, would not have any problem with making that test on the first flight. That's one of the advantages of a shuttle.

General **Abrahamson**. That's exactly right, sir.

Senator **Schmitt**. But you ought to know the cost trade-offs, I would think.

General **Abrahamson**. Yes.

Senator **Schmitt**. Dr. Weiss, are you comfortable with the long-term suitability of the computer support for operational Shuttle flights? You know, the reason for this is that we sort of made a decision to stick with the old at the mission control center, rather than to go to new computer concepts. And we're moving into the 1980s and 1990s with that very old system as the mainstay of operational activity.

Dr. WEISS. I'd like to answer by saying, first, that I'm comfortable with the near-term suitability. The longer-term suitability is something that, we consider worth investigating. We have established a task force under the auspice of both General Abrahamson's office and my own, as well as people from Johnson and Kennedy to review the whole data system, including the computer considerations. We expect to use outside personnel as well to evaluate that suitability. But, what we see is that in the next 4 to 5 years, we do have sufficient capability and we're looking at software modifications that will further enhance that.

Senator SCHMITT. Well, unless I'm mistaken, the Air Force plans for consolidated space operations center are currently geared to being compatible with the computer system at mission control center. I'm not sure yet what that means.

Dr. WEISS. I'm afraid that I can't define the compatibility aspect, either. There are many ways of making systems compatible, for example interfacing between even existing and more advanced computers, so long as you don't rule out methods of entry.

Senator SCHMITT. Has NASA been consulted by the Air Force in its CSOC software development and hardware development?

Dr. WEISS. Oh, yes.

General ABRAHAMSON. Yes, sir.

In fact, NASA has been working closely with the Air Force in terms of the interface and the concepts, as we have been in the design of Vandenberg itself. Like all designs, and I should probably use Vandenberg as a better example, it's a compromise, as we look ahead, between what we've got now and compatibility in future ideas. Perhaps the defense witnesses would care to comment on that. But, my own judgment is that there is time yet, as they proceed in the CSOC design, to evaluate that quite carefully to arrive at the best compromise.

Senator SCHMITT. I hope so. I do think that the Air Force had a legitimate gripe that the arrangement with NASA was overly constraining in the design of the Vandenberg facility. And my understanding is that that problem is being worked out or has been worked out.

I would hope that there would also be very strong liaison in the development of the CSOC. I've had the impression that this may not have occurred, and there was even testimony 2 days ago that suggested that NASA had not been very deeply involved in the Air Force conceptual design activity. We'll get more information on that later, of course, but I'd just encourage you to do everything that you can to assist them without overly constraining a modern operational control center development.

General ABRAHAMSON. I agree that the communications requirement is, a very fundamental one. That aspect has to be not only at project levels, but all the way up through the system so that there is confidence that this is going on. A recent development we have undertaken is one which we are fitting the NASA program into the management structure that the Air Force uses to control, examine, and review their programs.

All major programs, such as my former program, the F-16, are reported up through a chain to the Secretary of the Air Force periodically. Starting March 11, the Vandenberg program will be joined by myself, representing the NASA programs, and will brief them through that chain up through the Secretary of the Air Force. This will provide an additional high level forum for Secretary Orr and Mr. Beggs to discuss the problems as they see the total issue. I think that this is an important initiative.

Senator SCHMITT. Senator Cannon wished to have the following question asked. NASA plans 28 operational flights through fiscal year 1985, reaching a rate of 24 per year in fiscal year 1988. You indicate that the production of external tanks and solid rocket boosters is your limiting factor in even reaching 24 flights per year and that demand for the Shuttle in fiscal year 1985, and probably in fiscal year 1986, already exceeds the space available.

What can this committee do, in addition to approving your budget request, to help NASA increase the Shuttle flight rate?

Dr. WEISS. I think the considerations that we have applied in establishing the fiscal year 1983 budget are those that are related to the timing of the Shuttle's becoming operational which is a key factor in establishing limitations through fiscal year 1985. In terms of going beyond the 24 per year rate, we feel that the requirements we've seen to date will permit us to enter into the fiscal year 1984 budget those facilities, tooling and other equipments that would make it possible to exceed the 24 per year, if required. I certainly hope and expect that it will.

In terms of the support of the subcommittee, you've stated the first requirement, and that is support of our fiscal year 1983 budget request, as tight as it is, and also future support of our fiscal year 1984 planning, which is going to be ordered to meet the requirements for supply of those equipments, as well as facilities at Kennedy and at Johnson, which will satisfy further demand.

Senator SCHMITT. Well, I wonder if you would think about that for the record a little bit more and give us some details.

Dr. WEISS. I will, indeed.

[The following information was subsequently received for the record:]

Your offer to assist NASA in increasing the Shuttle Flight Rate is greatly appreciated. That assistance can best be provided, in addition to approving our current budget request, by supporting the key projects upon which the request is based. This would include, for instance, demonstrations such as the Solar Maximum Mission retrieval which we expect to both provide assurance for the unique use of the Shuttle in the modes required for this mission, and thus the assurance of corrective action necessary for downstream uses such as the Space Telescope. It will as well provide stimulus to potential users of this capability, in turn expanding the use of the Shuttle, demand for its services, and, therefore, the basis for the 1984 budgetary request which will be defined so as to support such a demand.

Senator SCHMITT. What else can we do to insure that NASA's Shuttle operations effort is not limited by its ability to market and compete? I think that's the concern of Senator Cannon, and it's my concern also, that because you have set, in a sense, an arbitrary limit, you have excluded yourself from marketing in that timeframe.

Dr. WEISS. I hope that's not the case. We have undertaken in recent months a far more aggressive marketing approach, certainly in response to the very active and successful marketing of the Ariane. We have had to utilize a combination of our expendible launch vehicles and the Shuttle in order to enhance our posture in a period when we do not have sufficient Shuttle space available. I think that this is an asset that the United States has that provides us a marketing stature that has received genuinely good acceptance outside.

In terms of what we need beyond this, we are developing a fairly formal marketing plan which we have under internal review. We've had one review of it with the Administrator, but we anticipate another session with him in the next couple of weeks. Under that plan, it doesn't appear that we see constraints that would require the support of the Congress to alleviate. But if we do, I believe that Mr. Beggs is very anxious to support a strong capability of furnishing capacity in the system to industrial and commercial users. And in order to generate the demand that will foster that capacity, I think that he is going to be a very strong supporter.

So if requirement exists, I have no doubts that he will find some ways of coming to the Congress.

Senator **SCHMITT**. When do you expect to have your new pricing policy available?

Dr. **WEISS**. We will have a new interim policy, serving 1986 and 1987, within the next 30 days. We've undertaken very strong scrutiny of the cost data base, which is going to be a very strong governing factor. As a matter of fact, we had a very extensive review of that yesterday. We will be discussing with Mr. Beggs next week the various options that we're examining to deal with the cost data base, cost recovery, and the competitive posture that we know we have to maintain.

Senator **SCHMITT**. Does that include a review of your current payment schedules in view of the very favorable terms being offered by our competitors?

Dr. **WEISS**. From a Shuttle standpoint, we have an extremely favorable pricing through fiscal year 1985. As a matter of fact, that period has turned out to be a very unique prospect to the user which is one of the reasons we have as many payloads as we can possibly handle even an excess of those.

The area in which we find ourselves in a less favorable position is with the expendable launch vehicles. We are examining the recovery of all reasonable costs—the means in which we charge for the launch vehicles to see if we're not loading costs into the system which are not entirely appropriate. I'd like to see those costs come down.

As far as the Shuttle is concerned, we expect to have a competitive price, but we are, in fact, fixed through fiscal year 1985 with our current price.

Senator **SCHMITT**. Are you considering a delayed payment schedule such as is being utilized by the French?

Dr. **WEISS**. We are not considering that at this time. We are talking with the financing houses, who are really the agencies that are going to have to deal with that sort of financing. Frankly, we use our reimbursements as we get them to pay for the procurement of the expendables. Those usages are very important to us and are offset, obviously, only by the appropriations that we seek. Those usages are one of the means we have for sustaining the total funding requirements for the system.

The answer to your question is that we are not considering a delayed payment schedule. But, we are actively talking to the financial resources that our customers use. In terms of our foreign customers, we have mentioned our discussions with the Export-Import Bank, who have offered that sort of payment schedule.

Senator SCHMITT. Now are all of these considerations based on a four- or a five-orbiter fleet?

Dr. WEISS. Our considerations are based on an active four-orbiter fleet. In other words, we do not have——

Senator SCHMITT. You're assuming the existence of the fifth orbiter to take up any contingencies of accident or national security priorities.

Dr. WEISS. I believe that by the time we're at a 24 per-year mode, we should very definitely have a fifth orbiter on hand to preserve the capability that the four orbiters operating system gives us.

Senator SCHMITT. Have you done a contingency analysis of circumstances that might arise where, suddenly, national security interests required a reduction in the launch schedule for commercial and nondefense satellites?

Dr. WEISS. Yes; we have done a number of contingency studies that relate not only to national defense preemption of the launch schedule, but also to the implications of down time for traumatic problems or even minor problems that would keep us from flying one or several orbiters for periods of time, ranging over 3 to 6 months, and up to 1 year. Those are the specific scenarios.

Senator SCHMITT. Could you provide the committee with a summary of those?

Dr. WEISS. Yes.

Senator SCHMITT. Obviously, I'm sure that they are in much more greater detail than we would be able to assimilate, but a summary of the contingency planning that you've done would be very helpful. And the options that you have considered.

[The following information was subsequently received for the record:]

We have examined the impact of various Space Shuttle service outages and the ability to recover from the outages. The years 1985 and 1987 were selected as representative of early operational flows and steady-state operations respectively. In each year, but separately, both fleet outages and single orbiter outages were examined and for various time periods of the outage. It was also assumed that the fifth Orbiter would be available at the time of the 1987 outage but not the 1985 outage.

As per the assumptions in 1985, from one to six Shuttle flights could be lost for fleet outages of from one to six months duration. For the less severe case where only one Orbiter is grounded in the same year, up to two flights would be lost for outages of one to six months and up to four flights if the outage is 12 months. Our flight rate for fiscal year 1985 is 13 flights.

Likewise, in 1987 from two to ten flights may be lost for fleet outages of from one to six months. The increase in lost flights is to be expected since the traffic continues to grow over this two-year period. For one orbiter outage and five orbiters available, no flights would be lost due to the availability of the fifth orbiter and the reduced demand at VAFB during the buildup period at the west coast. The fifth Orbiter provides a measure of reserve capacity in fiscal year 1987.

Recovery from these outages can be accomplished in several ways: reducing the shuttle turnaround time between flights; increasing the work shifts of the ground operations teams; and/or retaining expendable launch vehicles (ELV) to accommodate the communications payloads portion of the affected customers. Turnaround time reductions are accomplished by deferring or rescheduling payload launches such that the requirements for reconfiguring the orbiters between launches are minimized. Using this technique permits recovery to baseline operations in two to three years, but causes some payload slips of an equivalent time.

Applying overtime at the launch site for the ground operations crews can contribute to overcoming the impact of outages. In this case, it requires from one added shift for minimum losses of flights to full seven day-three shift operations in the event of maximum losses. The recovery time is still from two to three years. Some combinations of these two approaches for increasing the Shuttle flight rate would have to be implemented to minimize the adverse affects to both the payload community and operations teams. Characteristically, about a 20 percent reduction in turnaround time accompanied by a six day-three shift operation would permit recovery in two to three years.

Because about one-third of the Shuttle traffic in the foreseeable future is comprised of U.S. commercial and foreign communications users, retention of some level of ELV capability would be instrumental in offsetting the impact of Shuttle outages. If ELV's were used to fly the communications payloads, the number of Shuttle flights required to fully recover would be reduced to two-thirds of the losses, and, likewise, about one year would be saved in the recovery time requirement.

Senator SCHMITT. General Abrahamson, do you expect to continue to produce the steel SRB's?

General ABRAHAMSON. I think that question hinges on the economic point that I made earlier. If we can, in fact, produce a filament-wound-case version that is sufficiently reusable and is more economic, we would then like to phaseout the steel case, because even if that performance is not required for any one particular payload mission, what it does do is allow us to operate at a lower main engine setting, and therefore, achieve longer main engine life.

Senator SCHMITT. OK, that was my next question. Have you made that analysis yet of what you expect the impact on engine life to be?

General ABRAHAMSON. No, sir, we have not. Clearly, we will.

Senator SCHMITT. Is that a major consideration in the development of the filament-wound case, or is that a side benefit?

General ABRAHAMSON. I think it's an important consideration. The first consideration, however, is to get to the 65,000-pound payload that we advertised many years ago from the eastern launch site and the [deleted] payload that we advertised in a north-south orbit.

Senator SCHMITT. It's my understanding that there will be a getaway special on STS-3; is that correct?

General ABRAHAMSON. The getaway special on STS-3 will not be a complete package. Stan, I'd like you to describe that. I think the important aspect of it is that we have the first of the secondary school experiment programs scheduled to fly on STS-3. It is an attractive experiment by a young man who will be experimenting with flying insects in zero gravity.

Dr. WEISS. The STS-3 mission will actually carry the canister that we use for containing the getaway special experiment. So, it will be a proof test for the canister. On STS-4, we would be hoping to fly the first of the actual getaway special missions.

Senator SCHMITT. So NASA has been bugged, huh?

General ABRAHAMSON. Yes, sir.

Senator SCHMITT. I almost resisted that. What are the current cost estimates for the solar maximum mission?

General ABRAHAMSON. We've looked at it very carefully. What we have done, is to reduce the impacts in the early years, particularly by being able to achieve a direct-ascent orbit. By doing that, we have eliminated the need for an accelerated production and delivery of a mini-OMS payload bay kit approach that was previously considered. Therefore, for fiscal year 1982, we're looking at about an $18.2 million expenditure and for fiscal year 1983, a $23 million expenditure.

Senator Schmitt. Could you very quickly summarize why you think you have to demonstrate the capability before you can sell it? Certainly, we have had men work extravehicular activity in space. I admit, there has always been a reluctance in NASA management to acknowledge the fact that men work very well in extravehicular activity. That's, I guess, understandable.

But, really, if we're doing our job right, why do we have to have a demonstration of this capability before the Air Force or anybody else will believe that we can do it?

General Abrahamson. I think it goes beyond a demonstration, although I think a demonstration is important. First of all, it will allow us to extend the life of the solar maximum mission.

Senator Schmitt. But, General, the justification that I've heard from your bosses is almost always related to demonstrating the capability.

General Abrahamson. Yes.

Senator Schmitt. It was not initially justified on doing what the Shuttle was designed to do and that's repair or retrieval. It was justified on demonstration.

General Abrahamson. I'll give you my personal opinion, As I indicated earlier, the problem is that people don't recognize that the Shuttle really represents a capability to change in a cultural way, our approach to space, the way in which we approach the development of spacecraft and their use.

What does that mean? That means that we have to change a great deal of thinking in the way our present companies approach development and what they're trying to do. You don't get changes in culture easy and every time you can do a demonstration that proves these kinds of things, I think we can get a quantum jump in getting people to look at our capabilities in more imaginative ways.

Senator Schmitt. Well, wasn't anybody watching Skylab 1?

General Abrahamson. I was, sir.

Senator Schmitt. Didn't we demonstrate, basically, the inherent cultural capability to do all of these things with Skylab 1?

General Abrahamson. I think that's true. But, what we have not seen yet is a fundamental change in the way the development community is looking to expand the use and capitalize on the Space Shuttle itself.

Senator Schmitt. Is one more demonstration going to make the difference if they don't believe it now?

General Abrahamson. Not just one. I think we have to do a series of things.

Mr. Weeks. Senator Schmitt, the SMM retrieval will be the genuine proof that the two manned maneuvering units that we're buying—the first one comes in November of this year and the next one in August 1983—will really prove that we can stop the spin of this spacecraft to make the retrieval. It will prove out the manned maneuvering unit in a true demonstration. So, whatever customers there may be, Defense or other people, will know that the MMU is truly checked out and is an operating device because it was used to spin down an actual satellite. That's what we'll prove by the solar maximum mission retrevial.

So, I look at it as not just demonstration, but as a genuine proof of the MMU.

Dr. **Weiss**. Mr. Chairman?

Senator **Schmitt**. Well, but, again, I think that we—my problem is that, as I indicated 2 days ago, we're looking at some very critical things that NASA is deciding not to do, at the same time that they feel they have to demonstrate something that some of us feel we have already demonstrated, such as the Centaur. The money's not there, I'm told, now. We're going to close out that line, close out that capability, at least, to produce a high-energy upper stage that is Shuttle-compatible. Meanwhile, we're going ahead with these kinds of things. And when I compare the national need for a high-energy upper stage with the demonstration that you have described, I have a hard time saying that they're equivalent, or even that the demonstration you describe is more important.

Dr. **Weiss**. Mr. Chairman, I'd like to comment that none of us would disagree with the necessity for a high-energy upper stage. We're dealing with a project in the solar maximum mission retrieval which has a different character and also a vastly different investment requirement in the periods that we're talking about, a factor of 10 in 1983, and I certainly wish that we had that factor of 10 available for the high-energy upper stage.

On the other hand, the demonstration aspect is extremely valuable to NASA, as well as future customers. For example, we will need to refurbish the Space Telescope after it is launched, which requires working with a $725 to $775 million of the fiscal year 1983 budget investment in 1985. The means by which we work that system and make it a true national observatory is by being able to retrieve and refurbish the system.

Senator **Schmitt**. Well, Doctor, let me put it this way. If you, for some reason, in an attempt to do the solar max repair mission, were not successful, you didn't achieve the right orbit, you're still going to fly the large Space Telescope and you're still going to plan to do everything that you just described with it.

Dr. **Weiss**. We would have profited tremendously from the problems that we saw develop on the solar maximum mission.

Senator **Schmitt**. I wonder. I wonder if we haven't already seen those kinds of problems. Again, I think that there is an inherent distrust of the capabilities that men can provide in extravehicular activity because you've never done it. We've had that problem with NASA for years. Every since we have started, there has been this reluctance of people who have not done it, physically done it, to assume that we have that capability, and it's far broader than ever planned for.

If Skylab 1 didn't demonstrate that, the orbital, weightless activities, I don't know what it's going to take. And if you don't want to use the high-energy upper stage comparison, look at what we're doing to the aeronautics program, for crying out loud. That's what this committee has to look at. We have to look at the balance. And it is very difficult for many of us to see the solar max repair mission as competitive with the things that we've done to the NASA budget in other areas that have equally broad national significance.

Let's leave it there and you know our concerns. Gentlemen, I thank you very much. We'll have questions for the record. I wish that we could go on, but we must proceed with our other witnesses.

[The statements follow:]

STATEMENT OF MAJ. GEN. JAMES A. ABRAHAMSON, ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEM, NASA

Mr. Chairman and Members of the Subcommittee:

Thank you for this opportunity to present NASA's Space Transportation Systems (STS) budget request for FY 1983. The responsibilities of the Office of Space Transportation Systems includes the Space Shuttle Programs - Orbiter, Main Engine, Systems Engineering and Integration, and Ground Systems and Flight Test; as well as the Upper Stages, External Tanks (ET), and the Solid Rocket Booster (SRB); and Advanced Programs for the study of future space equipment and transportation systems.

Additionally, under a recent NASA reorganization this office is now charged with planning and approval of Institutional Management at the Kennedy Space Center (KSC), Marshall Space Flight Center (MSFC), Johnson Space Center (JSC) and the National Space Technology Laboratories (NSTL).

I would like to use this occasion to express my pleasure at being assigned to NASA as the Associate Administrator for Space Transportation Systems. It is an honor to be able to work with such a talented and dedicated organization. I also look forward to working with this subcommittee which has given such strong support to our Nation's space programs.

The goal of Space Transportation Systems is to provide an effective, efficient and reliable transportation system. The key to this system is the Space Shuttle, conceived in the late 1960's and given the Presidential go-ahead January 5, 1972. After many years of development on this complex vehicle, this past year we witnessed the first two orbital flight tests of the Space Shuttle.

Both flights were highly successful in more ways than just meeting flight objectives. I feel, Mr. Chairman, these successes have given not only those of us directly involved in the program, but the Nation as a whole, an overwhelming sense of national pride. From an engineering viewpoint we could hardly have done much better.

Columbia, flying the first Space Shuttle mission as STS-1, was launched April 12, 1981 from the Kennedy Space Center. Overall system performance during ascent was excellent, with all propulsion systems operating flawlessly. All subsystems performed according to specifications during on-orbit operations, reentry and landing. Astronaut reports on the vehicle were very complimentary with special emphasis on the orbiter's handling characteristics.

With the landing at Edwards Air Force Base (EAFB) on April 14, 1981, all major flight objectives were met successfully.

The number of problems encountered during the STS-1 mission were less than expected for a system of this complexity. The most significant problem was a reflective shock (overpressure wave) at SRB ignition. The SRB ignition overpressure produced higher than predicted structural loading in the orbiter which led to test and installation of an overpressure suppression system for the second launch.

After a launch scrub on November 4, STS-2 was launched November 12, 1981. Overall systems performance during ascent was, again, excellent and quite similar to STS-1. Orbiter subsystem performance on-orbit was, on the whole, very good. However, a fuel cell problem was encountered during the first day. Although we had reason to believe Columbia could well have flown the full five-day mission on the remaining two fuel cells, we elected to follow the conservatively written flight rules and implement a minimum (54-hour) mission. Even with this preplanned shorter mission, nearly all the major STS-2 mission objectives were achieved, including test of the Canadian developed Remote Manipulator System (RMS), and demonstration of orbiter capability to support attached payloads. Following an accelerated crew activity timeline, 90% of the STS-2 high priority flight objectives were achieved, and, 70% of the payload data was acquired. The astronauts again noted the excellent flying capabilities and achieved a nominal reentry and landing at EAFB on November 14, 1981. The completion of the STS-2 mission demonstrated orbiter reusability, the importance of the crew in contingency situations, and the excellent coordinated reaction of the flight crew and mission controllers under flight conditions.

The Orbiter Thermal Protection System (TPS) damage was significantly reduced from that encountered on STS-1. SRB ignition overpressure was about 25% of that measured on STS-1 and structural loads were well within design limits, indicating that pad modifications had solved the overpressure problem. The fuel cell problem has since been determined to be an isolated case of contamination and is not generic to the design itself. These and other minor problems are typical of a flight test program. Thus, these first two flights demonstrated the Space Shuttle as a viable new mode of space transportation.
The Space Shuttle Columbia is scheduled for launch next month on its third orbital flight test as STS-3,

a seven day mission. Carrying the OSS-1 science payload, STS-3 will also expand on tests done on previous STS flights but under more demanding conditions. Additionally, the long duration mission will permit a significant thermal exposure test to be conducted to determine the ability of the orbiter to maintain structural and systems temperatures within acceptable thermal - hot and cold - limits during prolonged attitude hold periods of up to eighty hours. STS-4, the final orbital flight test, will be flown in July.

The success of the first two flights has created a very positive attitude, leading us to concentrate even harder on ways in which we can reduce program costs and improve operations. To achieve these goals we will continue to view this as a total national space effort led by a NASA/DOD/industry team, aware of the nation's civil and national security needs. I am sure we will earn your and your colleagues' continued support in bringing what can be a powerful tool for the future --- The Space Shuttle --- on-line and into service. The first steps have been taken.

Mr. Chairman, we recognize that many of the economic woes of our country stem in part from decreasing productivity, and we are studying efforts to reduce this trend. As a first step we have established an agency-wide productivity improvement program to improve and demonstrate productivity improvement methods, procedures, quality, motivation -- every aspect of our business. The MSFC has been named to lead a sixty day study which I fully expect will provide bold ideas and practical initiatives. The program kickoff symposium, held February 8 at MSFC, was attended by teams from each NASA center and industry representatives.

In addition, NASA in coordination with the Aerospace Industries Association and the National Security Industrial Association is sponsoring a special product assurance symposium and a series of workshops to look at assurance techniques to support increased productivity. This activity is scheduled for early May, 1982.

On a related aspect, we are continuing to support the President's Office of Science and Technology Policy Study which deals with such questions as management of the operational Space Shuttle and how long we should continue use of expendable launch vehicles. This study is expected to be completed this summer.

FY 1982 Operating Plan

Before I address the FY 1983 funding request, I would like to comment on the FY 1982 operating plan which reflects a decrease of $31 million in the Space Shuttle below the amounts requested for FY 1982. This is a net adjustment, comprised of a reduction of $36 million and the inclusion of a $5 million reprogramming from Space Flight Operations to Space Shuttle for the proposed initiation of development on the filament wound case for performance augmentation. The $36 million reduction results from the allocation to the Space Shuttle of the general reduction in funding pursuant to Section 501 (41) of the HUD-Independent Agencies Appropriations Act. Within Space Shuttle program funding, the reduction was made to Changes and System Upgrading, thereby reducing the amount in this account from $300 million to $264 million. Subsequently, the $264 million in Changes and System Upgrading has been allocated to fund the increased requirements of $158 million and $106 million we now recognize in both the DDT&E and the Production phases, respectively.

In Space Shuttle DDT&E, the three principal areas requiring additional funding are: the orbiter, to which $50 million has been applied, to provide for additional engineering requirements at Rockwell for Orbiter development and systems engineering and at JSC to support continued development of flight software, the Manned Maneuvering Unit, the activities supporting the proposed spacecraft retrieval/repair demonstration using the Solar Maximum Spacecraft, and the space suit; the External Tank, increased by $31 million, to cover delivery schedule adjustments on the STS-3 and STS-4 flight tanks and increased effort on tank producibility and production readiness; and, for launch support activities at KSC, $61 million, to cover the increased costs of supporting the Shuttle launch processing.

The remaining $106 million of Changes and Systems Upgrading funding is being applied to Shuttle Production requirements, principally in the areas of the Orbiter, Main Engine and Spares and Equipment. The increase in the Orbiter program element funding is $23 million, in part to implement changes authorized to improve the performance of subsystems such as the reaction control system, fuel cells, the TPS and for the modifications which will be made to Columbia following STS-4. The Main Engine requirements have increased $39 million as a consequence of the series of engine test failures last summer while the full power level engine was undergoing initial testing.

Design changes have had to be made and implemented and production engine delivery schedules significantly revised to assure that the full power level development and certification program may proceed without impact to the availability of flight engines for OV-099. Spares and Equipment requirements have increased $38 million. This increase is primarily due to revised assessments for earlier deliveries of orbiter spares and the higher than estimated procurement costs for small quantities of items. Procurement costs for spacesuits have also grown substantially from previous estimates.

The development of the Solar Electric Propulsion System (SEPS) which we have had under study to support solar system exploration missions has been deferred and a proposal to reprogram $3 million of FY 1981 SEPS appropriations for use in space platform studies has been submitted.

The FY 1982 Operating Plan reflects a major change with regard to Upper Stages to be used with the Space Shuttle. As you may recall, we initiated efforts to adapt Centaur for use as an STS Upper Stage for planetary missions. During the 1983 budget planning cycle, two planetary programs--the Galileo and the International Solar Polar missions were approved. The continued development of the long, more capable version of the Centaur could not be justified on these two missions alone. Therefore, a decision was made to terminate the Centaur/STS development activities in favor of flying the Galileo mission on a two-stage IUS and a kick stage. The European Space Agency International Solar Polar (ISPM) spacecraft will also be flown on a two-stage IUS with a kick stage. We continued to examine the possibilities of developing a shorter version of the Centaur to meet future DOD projected payload trends as well as NASA near term requirements. After careful scrutiny, it was judged to be infeasable to proceed on the schedule required for Galileo, within funding constraints as specific DOD requirements remain undefined at this time. However, the DOD and NASA plan to proceed in a deliberate, joint study effort as soon as possible to define future high energy upper stage requirements as well as the most cost-effective vehicles. The FY 1982 requirement for Upper Stage development has as a consequence of the above decision decreased from $75.0 million to $23.2 million.

FY 1983 Budget Request

With respect to the FY 1983 Budget Request, the total budget authority requested for Space Transportation

Systems in the Research and Development account is $3,467.8 million. In my testimony today, I will be addressing the elements within Space Transportation Systems for which I am responsible; Dr. Stanley I. Weiss, Associate Administrator for STS Operations, will, in turn, address the other elements of the STS Program: STS Operations, Spacelab, Expendable Launch Vehicles, and STS Operations Capability Development--excluding Upper Stages Development.

Within the $3,467.8 million overall request, an amount of $1,844.3 million is requested for the Space Shuttle and for the Space Flight Operations activities concerned with Advanced Programs, Upper Stages Development, and the Engineering and Technical Base.

SPACE SHUTTLE

The Space Shuttle request is $1,718.0 million in FY 1983. These funds will provide for the continuation of Shuttle Production, for the development of the SRB filament wound case to augment the Shuttle's performance, and for the Changes and Systems Upgrading which we recognize are needed to improve the ground and flight systems. No funding is being requested for the Design, Development, Test, and Evaluation (DDT&E) Program in FY 1983 based on the completion of the OFT missions this year. There will be some residual development activities which will be pursued in FY 1983 and subsequent years; these are primarily concerned with the analysis of the data gathered during the OFT and initial operational missions, with continuing effort to improve the External Tank's producibility and production readiness efforts, and with the Main Engine's full power level certification and life demonstration testing.

Production

For the Orbiters we are requesting $933.5 million. The Space Shuttle Production Program is based on a national fleet of four orbiters. They are the Columbia (102), Challenger (099), Discovery (103) and Atlantis (104). The FY 1983 budget request will support production on Orbiters 103 and 104, and modifications to Orbiter 102.

The Challenger, used in the Design, Development, Test and Evaluation program for structural testing, is being modified to an operational vehicle. The modification is nearing completion at the Palmdale Final Assembly Plant and is scheduled to be delivered mid 1982. No major problems have been encountered during integrated testing and we are predicting delivery this summer. Challenger's first flight is scheduled for January 1983.

Substantial progress has been made in production of Discovery. By the end of 1982 major elements are planned to have been delivered. Initial and final systems installations, factory testing and checkout will also have been completed. Discovery is scheduled for delivery in the fall of 1983.

The pace is picking up on the schedule for Atlantis. Assembly has started on the aft fuselage bulkhead, and hardware for other major elements is being manufactured. Deliveries of these major elements begin in late FY 1983 with arrival of the mid-fuselage at Palmdale. Planned delivery date of Atlantis is in late 1984.

Another major activity being funded in Shuttle Production is the modification of the Columbia to an operational flight vehicle. Initial modifications will be made at KSC prior to the STS-5 flight. Following this flight, Columbia will be returned to Palmdale for major modifications prior to being placed in operational use.

As the Congress requested, we are also investigating a fleet buy for our planned additional orbiters. It is believed that we might be able to achieve significant cost savings if we could buy the planned orbiters as a package rather than year by year. Also, a fleet buy would remove any doubts of potential users as to the long term availability of orbiters for meeting future flight rates.

For the Space Shuttle Main Engine (SSME), we are requesting $262 million in FY 1983. The SSME is the most efficient, high pressure liquid hydrogen/liquid oxygen rocket engine ever built. Unlike most previous engines, which had fixed power settings, the SSME is designed to be throttled from 65% to 109% of rated power during flight and is designed for reuse for up to 55 flights.

We are currently working toward development and certification of the Main Engine at full power level -- 109% of the thrust levels of the engines used on Columbia. The power increase will permit increased payload capacity and improved safety.

In the FPL development program we experienced two significant design deficiencies during ground testing last year, resulting in major damage to three development engines. The problems, main injector lox post cracking and fuel preburner injector element cracking, were unique to the FPL operations and design fixes have been established and are now being tested. The FPL certification testing is scheduled for completion in early 1983.

In Spares and Equipment, our FY 1983 budget request of $323 million is required for the initial lay-in of replacement spares for Shuttle components, tooling requirements to achieve higher production rates of ET's and SRB's and procurement of orbiter flight spares and crew equipment.

Initial spares include primarily line replaceable units, or those items for which the optimum maintenance is removal and replacement. These are considered an investment in assuring flight rates and processing times required for operational missions.

ET producibility efforts will continue in FY 1983. Our goal is to reduce future ET costs by identifying producibility improvements in assembly and manufacturing operations. Our production capacity now stands at 10 to 12 tanks per year with plans to increase the production rate to 24 per year by 1987. Clearly, we must make the transition from a development program to on-line production status as soon as possible. This transition offers us a clear target for productivity enhancements aimed at reducing the time and cost of building the tanks. Areas currently under scrutiny include improved welding techniques, automated inspection systems and alternate insulation foam materials. However, it is not just labor and techniques that contribute to increasing productivity; management and operations control methods also are being analyzed, including hardware flow to identify choke points, refinement of work standards, inventory control, labor reporting and discrepancy processing systems. Solid Rocket Booster and other production and management areas also are under the same type of analysis.

In FY 1983, the second test firing and verification of the Solid Rocket Booster's high performance motor (HPM) will be completed to support a summer 1983 launch. The HPM design involves minor changes to the thrust/time profile, throat diameter, and nozzle expansion ratio to provide a payload increase of 2000 lbs. Development firing is planned for the summer of 1982 and qualification firing in early 1983.

In Production Launch and Landing, the thrust of FY 1983's funding request of $67.0 million will be to design, install, checkout and validate the second line of processing facilities, including the SRB segment processing and storage facility, the second launch pad and the DOD secure third firing room. The SRB motor facility construction, to be completed in FY 1984, will support receiving, inspecting, rotating, testing and storing of segments, including aft segment buildup prior to stacking on the mobile platform in a high bay of the vehicle assembly building (VAB). To support the operational readiness date of the second launch pad in FY 1986, intensive efforts have begun to initiate plans and long-lead procurements for ground support equipment. Several design changes must be incorporated in the second pad as a result of knowledge gained from the first Shuttle flights. These include the ET gaseous oxygen vent collector, SSME hydrogen pre-ignition igniter and water systems modifications for pre-flight SSME shutdown and the SRB overpressure wave attenuation. Firing room three in the Launch Control Center will be modified and activated for DOD missions requiring secure operations. We plan for these actions to be completed in FY 1983 to support required launch rates including critical DOD launches scheduled.

Changes and Systems Upgrading

Management, technical and cost reviews of the Space Shuttle program and flight experience and ground testing have pointed to the need for an adequate allowance for changes and modifications which are inevitably required in a large, complex and technically demanding space system. To provide for these needs we are requesting $72.5 million in FY 1983.

This funding request represents the amount required to initiate modifications to improve reliability, increase operating efficiency and reduce cost. Specific changes and system upgrading enhancements include: the reaction control system, a redesigned auxiliary power unit, landing gear improvements, minor modifications to the SSME, tape recorder upgrading, increased Orbiter autonomy for onboard checkout, and control, procedure, and hardware changes. These would reduce turnaround time, enhance operational capability, and reduce the cost per flight.

Performance Augmentation

We are requesting $60 million in 1983 for the Performance Augmentation program to provide increased payload delivery capability to meet NASA's long standing commitments to the Department of Defense users for performance of critical missions at the Vandenberg Launch Site (VLS). This increased capability is required to support the first DOD Space Shuttle flight at VLS in 1985.

Based upon comprehensive NASA/DOD assessments of mission requirements and detailed systems engineering and tradeoff studies of several performance augmentation options, we have decided to provide this increase in performance by reducing the inert weight of the SRB's by using lighter filament wound motor case segments to replace the heavier steel. Total weight reduction is expected to be about 65,000 pounds giving an added payload advantage of about 6,000 pounds. This augmentation in performance will be applicable to missions launched from the Eastern Launch Site as well as the VLS. We believe a development schedule which would make the cases available in 1985 would provide the margins for critical missions without resorting to expensive measures to increase the payload capability that would otherwise be necessary.

SPACE FLIGHT OPERATIONS

We are requesting $126.3 million for those portions of Space Flight Operations which include the Engineering and Technical Base support, Upper Stages Development and Advanced Programs. These activities are necessary for the orderly transition to full operational status.

Engineering and Technical Base

Starting in FY 1983, Development, Test and Mission Support (DTMS), has been redefined and retitled Engineering and Technical Base (ETB). ETB will provide only the minimal (core) capability to sustain an engineering and development base to support various STS systems at JSC, KSC, MSFC and NSTL. The ETB also provides necessary equipment and supplies and performs alternative design, testing, and analyses in high technology areas of design and development. This core capability provides for a five day, one shift operation at designated institutional research and development facilities. The budget estimates for other NASA programs includes funding for the additional support required to carry out specific program activities. We are requesting $82.4 million in FY 1983 for the Engineering and Technical Base.

Advanced Programs

Advanced Programs encompasses studies and engineering investigations which continue to define future flight mission options to use the unique capabilities of the Space Transportation System starting in the mid-1980's. The FY 1983 budget request is $11.9 million for these tasks. Supporting engineering activities and subsystem studies will also be conducted to provide the technical depth essential to the definition of these potential systems, thereby reducing future program development costs and risks. Attention will be directed toward enhancing the effectiveness of the Space Shuttle, particularly toward extending its orbital capabilities.

We are also studying and planning advanced development activities on unmanned space platforms and manned space stations should we have a need for a permanent manned presence in space. We have defined an unmanned platform which could support science, applications, and commercial experiments and then grow to become a space station by the addition of the appropriate habitation and utility modules. We are also defining, in parallel, an evolutionary Space Station program which could begin as a manned facility and grow in capability by modular add-ons.

These platforms and space station could fulfill a number of possible future functions such as servicing of other satellites in low orbits and refueling orbit transfer vehicles for emplacing and servicing satellites in geostationary orbits. They could also provide economical and versatile test facilities for R&D and science activities. A program plan is being defined to determine possible approaches.

In addition, we will increase our emphasis on understanding, quantifying, and meeting the needs of the user communities in all the above areas for which the STS is a service and support function in order to define meaningful space systems.

STS Operations Capability Development
(Upper Stages Development)

We are requesting $32.0 million in FY 1983 for Upper Stage Development. Upper Stage vehicles are required to place payloads into orbits not attainable by the Shuttle. The Upper Stages under development include the Inertial Upper Stage (IUS), a two stage solid propellant expendable vehicle capable of delivering 5000 pounds into geosynchronous orbit, and the Spinning Solid Upper Stages (SSUS), used for delivery of smaller, Delta and Atlas Centaur classes, payloads into geosynchronous transfer orbits.

The IUS program has been managed by the DOD and jointly funded by NASA and DOD. Development of the two stage configuration for geosynchronous missions has made significant progress during the year with 50 of 53 major components now having been qualified. The first qualification motor firing has been successfully conducted and four flight motors have been cast. Shipment of IUS-2 for the first Titan launch was made last December.

The commercial development by McDonnell Douglas of the Delta-class SSUS is proceeding with the principal activity being continuation of system level qualification, and fabrication and checkout of hardware for STS flights. SBS-B, RCA-D, and RCA-C spacecraft have been successfully launched during the year, using the smaller SSUS on the Delta expendable launch vehicle.

Additionally, under Advanced Programs we are exploring advanced Upper Stages known as orbital transfer vehicles to introduce stage reuse and payload retrieval capabilities.

Research and Program Management
(R&PM)

As stated earlier, the December 1981 Headquarters' organizational change provided for the Johnson Space Center, the Kennedy Space Center, the Marshall Space Flight Center, and the National Space Technology Laboratories, to report to me as the program Associate Administrator responsible for the major portion of their in-house technical capability. The R&PM appropriation provides the funding needed to maintain the in-house support capability necessary to fulfill the R&D Program responsibilities assigned to centers reporting to me. Approximately three fourths of the R&PM funds pay the salaries of the highly successful and dedicated Civil Service scientists, engineers, technicians, administrative, and clerical personnel who are essential to the execution of our R&D programs. These skilled people are our most valuable asset. The remaining one fourth provides for the necessary travel and institutional supplies, materials, equipment, utilities and services to support our civil service staff and operate the centers. The travel budget proposed for FY 1983 is the same level as FY 1982, which will result in an actual decrease in travel due to higher costs.

Johnson Space Center (JSC)

JSC is the lead center for the management of the Space Transportation System and historically has been NASA's primary center for manned space vehicle developments and space operations. An R&PM budget of $192.4 million is requested for JSC in FY 1983. It provides $137.6 million for personnel and related costs to support 3,293 permanent civil service positions. The FY 1983 budget request also provides $50.2 million for the operation of the installation; this amount will meet expected increases in support service costs and utility rates while providing essentially the same overall level of service.

Kennedy Space Center (KSC)

KSC is the primary NASA Center for assembly, test, checkout, and launching of space vehicles. This includes refurbishment of the Space Shuttle as well as the assembly, test, checkout and launch of expendable launch vehicles.

An FY 1983 R&PM budget of $169.5 million is proposed. Of this sum $83.4 million is for personnel and related costs to support 2,112 permanent positions. The operation of installation is estimated at $84.4 million. This provides for expected rate increases in both the utility and support contractor areas. This last category provides centralized institutional and administrative services to the total center population which has grown to 14,000 including contractor and civil service employees.

Marshall Space Flight Center (MSFC)

MSFC is one of NASA's primary centers for the design and development of space systems and science and applications payloads and has the principal role for rocket propulsion within NASA.

We are requesting an FY 1983 budget of $177.7 million. The personnel and related costs of $132.5 million provides for 3,285 permanent positions. The operation of installation estimate of $41.7 million is to meet projected increases in support contractor wage rates, supplies, materials, utility rate increases, and the purchase of a replacement administrative aircraft. As you may recall, NASA initiated in the FY 1981 budget the planned replacement of three administrative aircraft and the procurement at MSFC represents the completion of that plan.

National Space Technology Laboratories (NSTL)

NSTL is NASA's prime static test facility for large liquid propellant rocket engines and propulsion systems. It also provides support to a number of tenant agencies co-located at the laboratory.

The FY 1983 budget request of $6.3 million provides essentially the same level of personnel, travel, and operation of installation suppport services as FY 1982, including projected rate increases.

Construction of Facilities
(C of F)

As the Director of Facilities will address the total agency C of F budget request, I will confine my remarks to a general overview of the Facilities Program that is directly related to Space Transportation Systems (STS) and our STS field installations. In the $100 million C of F budget request, $23.1 million is for STS major facility projects. The bulk of this request, $17.8 million, is for modifications to our manufacturing and final assembly facilities for the External Tank at the Michoud Assembly Facility.

In addition to the major projects, approximately $15 million is needed for minor projects at the STS field installations. These projects are critical requirements for maintaining and improving the usability of our facilities for research, development and launch operations.

Although the C of F requirements for STS activities are small when compared to the R&D fiscal requirements, they are absolutely essential to the overall success of the Shuttle Program. I request your continued and full support of this element of the NASA budget request.

Mr. Chairman, this concludes my prepared remarks. Thank you.

SUBCOMMITTEE ON SCI [illegible]
COMMITTEE ON COMMER [illegible]

UNITED STATES

- GOALS
- FLIGHT SCHEDULE
- ORBITER PRODUCTION
- MANAGEMENT INITATIVIES
- PROGRAM SUMMARY

MAJOR GENERAL JAMES A. ABRAHAMSON
ASSOCIATE ADMINISTRATOR
OFFICE OF SPACE TRANSPORTATION SYSTEMS

Fig. 1

OFFICE OF SPACE TRANSPORTATION SYSTEMS

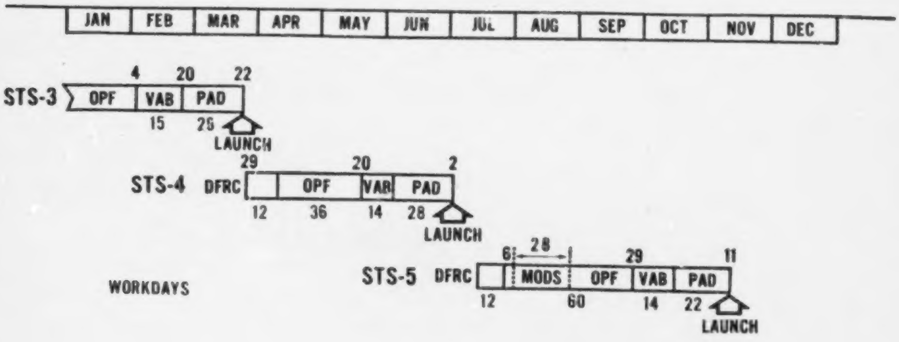
STS PROGRAM GOALS

- SAFE AND SUCCESSFUL STS MISSIONS
- MAINTAIN OPERATIONAL LAUNCH SCHEDULE
- REDUCE OPERATIONAL COSTS
- COMPLETE DDT&E
- MAINTAIN ORBITER PRODUCTION SCHEDULE
- COMPLETE KSC AND VAFB FACILITIES
- ESTABLISH INITIATIVES TO EXPLOIT STS CAPABILITY

[illegible] Fig.2

OFFICE OF SPACE TRANSPORTATION SYSTEMS

STS-3,-4,-5 1982 PLANNING SCHEDULE



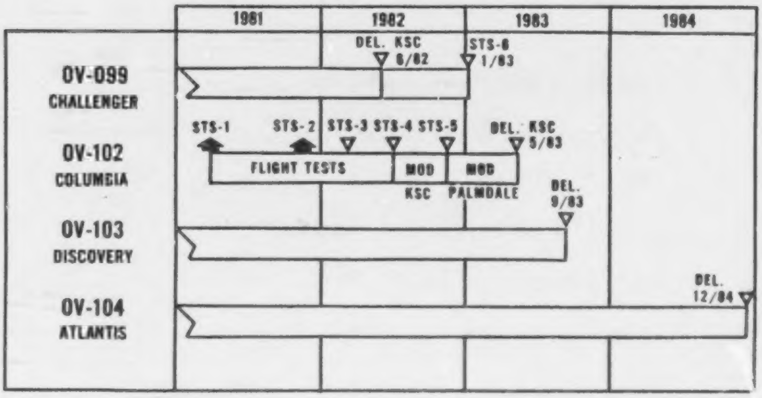
OPF-ORBITER PROCESSING FACILITY
PAD-LAUNCH PAD

VAB-VEHICLE ASSEMBLY BUILDING
DFRC-DRYDEN FLIGHT RESEARCH CENTER

Fig.3

OFFICE OF SPACE TRANSPORTATION SYSTEMS

ORBITER DELIVERY SCHEDULE



[illegible] Fig. 4

OFFICE OF SPACE TRANSPORTATION SYSTEMS

MANAGEMENT INITIATIVES

- REVISED FINANCIAL PLANNING
- STRONG OPERATIONS EMPHASIS
- ERROR-FREE OPERATIONS GOAL
- COST INCENTIVE CONTRACTING
- MANUFACTURING MODERNIZATION
- PRODUCTIVITY IMPROVEMENTS

Fig. 5

OFFICE OF SPACE TRANSPORTATION SYSTEMS

FY 1983 BUDGET
SUMMARY OF REQUIREMENTS

(DOLLARS IN MILLIONS)

	FY 1982	FY 1983
• SPACE SHUTTLE	2163.0	1718.0
DDT & E	898.0	–
PRODUCTION	1260.0	1585.5
CHANGE & SYSTEMS UPGRADING	–	72.5
PERFORMANCE AUGMENTATION	5.0	60.0
• SPACE FLIGHT OPERATIONS	895.9	1707.0
DTMS/ENGINEERING & TECHNICAL BASE	184.0	82.4
ADVANCED PROGRAMS	8.8	11.9
STS OPERATIONS CAPABILITY DEVELOPMENT	79.3	85.4
(UPPER STAGES DEVELOPMENT)	(23.2)	(32.0)
SPACELAB	100.8	113.2
STS OPERATIONS	523.0	1414.1
• EXPENDABLE LAUNCH VEHICLES	31.2	42.8
TOTAL	3090.1	3467.8

Fig. 6

SPACE TRANSPORTATION SYSTEMS

RESEARCH AND PROGRAM MANAGEMENT

(DOLLARS IN MILLIONS)

CENTER	CURRENT ESTIMATE FY 1982	BUDGET FY 1983
JOHNSON SPACE CENTER (JSC)	$186,635,000	$192,396,000
KENNEDY SPACE CENTER (KSC)	163,441,000	169,500,000
MARSHALL SPACE FLIGHT CENTER (MSFC)	170,840,000	177,704,000
NATIONAL SPACE TECHNOLOGY LABORATORIES (NSTL)	$ 6,086,000	$ 6,252,000

Fig. 7

SPACE TRANSPORTATION SYSTEMS

FY 1983 BUDGET ESTIMATES CONSTRUCTION OF FACILITIES

• SPACE SHUTTLE	$21,405,000
MAF	17,845,000
KSC	1,700,000
VARIOUS LOCATIONS SHUTTLE-UNIQUE PROJECTS (LESS THAN $500,000 EACH)	1,860,000
• PAYLOADS	$1,740,000
KSC	1,740,000
• MINOR REPAIR PROJECTS	
50 PROJECTS AT (LESS THAN $500,000 PER PROJECT)	$14,650,000
TOTAL	$37,795,000

Fig.8

OFFICE OF SPACE TRANSPORTATION SYSTEMS

PROGRAM SUMMARY

- STS-5 BEGINS OPERATIONS
- MAINTAIN PRODUCTION FOR 32 FLIGHTS THROUGH FY 1985
- 24 FLIGHTS PER YEAR CAPABILITY BY FY 1988
- ORBITER DELIVERIES ON SCHEDULE
- PERFORMANCE CAPABILITY IMPROVEMENTS
  - 109% MAIN ENGINE (CERTIFIED EARLY 1983)
  - FILAMENT WOUND CASE (FIRST FLIGHT LATE 1985)
  - HIGH PERFORMANCE BOOSTER (FIRST FLIGHT MID 1983)
  - LIGHTWEIGHT TANK (FIRST FLIGHT EARLY1983)
  - MANNED MANUVERING UNIT DEVELOPMENT (SUPPORT SOLAR MAXIMUM REPAIR)
- FACILITIES AT KSC AND VAFB
  - SUPPORT VAFB OPERATIONAL DATE (LATE 1985)
  - COMPLETE SECOND KSC PAD (LATE 1986)

Fig.9

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR SCHMITT AND THE ANSWERS THERETO

SPACE SHUTTLE

Question. What is NASA doing to maintain the capability to acquire the long lead items for OV-105?

Answer. NASA has a study effort underway with Rockwell International to examine the benefits, tradeoffs and methods for implementing a block buy of OV-105/spares/ground support equipment and possibly coupling that with the remaining OV-104 effort.

The preliminary study results have shown cost advantages of a block buy, and more detailed planning is underway. We are also examining the budget considerations required to implement both the long lead and full procurements.

Prior to proceeding with OV-105 we would seek Administration and Congressional authority.

Question. How do you view your relationship with the DOD evolving over the next few years in particular with regard to Shuttle operations management? Please summarize what you see as the key elements involved in evolving the Shuttle into an operational system.

Answer. The NASA/DOD relationship spans more than 20 years. It has been a good and close relationship. That relationship will grow closer as we move into the operational phase of the STS due to increased support to the DOD in bringing the West Coast launch site at Vandenberg on-line and because the Space Transportation System will be the DOD primary medium to space in the future. Presently, we are jointly seeking ways to reduce program and overhead costs. Recently NASA and the Air Force have agreed to defer some early years costs at Vandenberg by utilizing Shuttle facilities at NASA's Kennedy Space Center to perform some Vandenberg checkout tasks. This results in significant early years savings in support equipment procurements and personnel costs. In addition, some tasks will be deferred permanently and we will continue to seek areas of optimization.

Launch facilities and external tank and solid rocket booster production rates are the primary constraints to achievement of an operational STS. Flight rate build-up is sensitive to improvements in turnaround flow at KSC, together with anomaly events impact and realistic budget constraints. Turnaround improvements will also reduce the overhead costs of launch and flight operations. Achievement of projected four to five week turnaround capability by the mid-1980's will require mechanical improvements, software changes, manifest optimization, requirements and checkout reduction, plus procedure maturity and heightened risk management. Flight rate build-up is also dependent upon orbiter fleet size, the production capacity for the ET and assembly rate and integration of the SRBs at KSC. Increased emphasis is being placed on efforts to improve producibility of the ET assemblies through improved welding techniques, automated inspection systems, and use of alternate insulation materials. Reduced turnaround in the mated integration and closeout of the SRBs will require procedural changes and system hardware enhancements.

Safe, efficient, and routine operations of the STS are necessities during the Shuttle operational transition phase and the period of flight rate buildup. With STS maturity, new institutional and contractual arrangements will be required for operational launch, flight and mission effectiveness. We have initiated studies and analyses to explore competing options and will report them as appropriate.

Question. What do you see as the major factors for reducing operational costs and thereby reducing pricing?

Answer. The major fctors that we are focusing our efforts on in order to reduce the cost of operating the Space Shuttle are:

(1) incentivizing our contracts for cost control and cost reduction, and wherever practical moving to fixed-price-type contracts;

(2) consolidation of related contracts under a single contractor with self-sufficiency provisions where appropriate. The KSC Base Operations Contract is an example of this consolidation approach.

(3) Automation of routine processes (e.g., preliminary mission design, reordering spare parts, generation of flight software) and information systems (e.g., work status, problem reporting, logistics data); and

(4) standardization of ground and flight operation processes and the stabilization of the flight hardware designs so that production/assembly processes are standardized.

New initiatives which are planned to reduce costs in the operations era by standardization are: standardizing ascent and descent profiles, payload/orbiter interfaces, and flight and ground software. In addition, we are investigating concepts which will provide autonomous payload command and data services, thereby eliminating future interactions between payload and orbiter systems and permitting greater standardization of the orbiter software.

Question. How much are you planning to spend in fiscal year 1983 on studies for a new generation of expendable launch vehicles? When were these studies initiated? Could you please describe your current activities?

Answer. The amount, if any, to be spent in fiscal year 1983 on new-generation reusable launch vehicles will depend on results of studies now underway. Present contracts, typically 8 to 18 months in duration, are as follows:

Subject	Center	Contractor	Initiated
SRBX unmanned launch vehicle	MSFC	Boeing	December 1981.
"In-Line" Shuttle-derived cargo vehicle	MSFC	Boeing	August 1981.
Several Shuttle-derived launch vehicles	MSFC	Martin	October 1980.
Shuttle-derived cargo vehicle	JSC	Rockwell	August 1981.

All of these studies are exploratory, trading off various conceptual system definitions to see if any is worthy of inclusion in a mixed fleet.

Question. What is the status of spacesuit development?

Answer. The Extra-Vehicular Mobility Units (EMU) were certified for use on STS-3 and were flown on STS-3—one for each astronaut. Since Extra-Vehicular Activity (EVA) was not planned for this mission, the suits will only be used in a contingency operation.

Because the EMU's are certified for the flight, the only changes currently underway are those necessary to correct problems discovered during training exercises (e.g. redesign in gloves and change to corrosion resistant parts in the primary life support system).

The current status of deliveries of flight hardware is as follows:

Life support systems—3 on-hand wth 8 more to be delivered by fiscal year 1987.

Space suit assemblies—12 on-hand with 42 more to be delivered by fiscal year 1988.

Efforts are underway to attempt to shorten or even eliminate the time necessary to pre-breathe (a denitrogenization process to eliminate the "bends") before conducting EVA.

These efforts are concentrated in two areas:

1. The increase of the suit pressure to 4.3 pounds per square inch (PSI) from the current 4.0 psi and lowering of the cabin pressure from 14.7 psi to 10.2 psi. Results of the study should be available in two months.

2. An 8 psi suit is being designed/developed by the Ames Research Center under a NASA research and technology project. This demonstration model is scheduled for delivery by the end of 1982 at which time the initiation of further testing will be reviewed relative to proceeding with 1. above.

Question. What is the current plan for production of Delta and Atlas Centaurs? Do those estimates include meeting Shuttle overflow?

Answer. The Delta and Atlas Centaur production lines are being maintained primarily with reimbursable user funds. Specifically, the Atlas Centaur production line is totally maintained by reimbursable customer funds since NASA has no current planned use for this vehicle. The Delta, however, is still being used for NASA missions (IRAS, Landsat-D, -D, and AMPTE) and will require appropriated funds in fiscal year 1983 and subsequent years.

The Delta and Atlas Centaur plans indicate firm requirements for communications satellites through 1985-86 primarily to absorb near-year Shuttle overflow. We are examining possible future requirements for an integrated fleet of Shuttles and expendables beyond 1986.

Question. What are the major reasons for the increases in resource requirements for the Space Transporation System in fiscal year 1983 as compared with the March 1981 projections?

Answer. The current fiscal year 1983 budget request for the Space Transportation System programs, which include the Space Shuttle, Space Flight Operations, and Expendable Launch Vehicles, is $445 million higher than the fiscal year 1983 estimate in runout of the fiscal year 1982 Amended Budget. This total of $445 million is comprised of increases of $187 million in the Space Shuttle; $243 million in Space Flight Operations activities; and $15 million in Expendable Launch Vehicles.

The Shuttle increase is primarily due to changes in three program areas: the $60 million included in the current fiscal year 1983 budget request for the filament wound case developement (there were no funds in the fiscal year 1982 Amended Budget runout) to provide performance augmentation for the Shuttle; an additional $172 million for spares and equipment requirements primarily due to price and quantity increases for orbiter flight and crew equipment spares, external tank and solid rocket booster rate tooling and external tank producibility and production readiness efforts; and a $55 million reduction for Shuttle/Centaur modifications related to the decision to discontinue the development of the Centaur upper stage. Other increases totaling approximately $73 million have occurred in a number of Shuttle activities including systems integration efforts, post orbital flight test (OFT) data analysis, modifications to Orbiter 102, spacesuit hardware production, simulator/trainer modifications, and solar maximum mission unique requirements. These increases have been offset by an allocation of a like amount from the previous fiscal year 1983 estimate for the Changes and Systems Upgrading budget.

In the Space Flight Operations line item, the increase of $243 million is comprised of approximately $280 million for Shuttle Operations manpower and hardware; $17 million for multi-mission payload support equipment and manpower increases required for the upgrading of the Mission Control Center capability; and $15 million for Spacelab development for systems integration, flight hardware modifications and spares and ground support equipment. These increases have been partially offset by decreases of $60 million in upper stages development and operations related to the discontinuation of the Centaur upper stage development and $8 million in payload support operations requirements.

The Shuttle Operations increase of $280 million includes an additional $135 million for Johnson Space Center activities for mission operations manpower and to procure orbiter vehicle spares and equipment which increased in quantities as well as unit costs, and $115 million increase for Shuttle processing and launch operations manpower at the Kennedy Space Center. The manpower increases at both centers result from the requirement to maintain the current level of manpower as the STS transitions from development to the operational era. These levels of manpower established by STS-1 and STS-2 experience must be maintained until additional experience in operating the STS is gained and anticipated efficiencies are realized which would allow for reduced manpower requirements. Production of solid rocket boosters and external tanks for operational flights have increased by approximately $30 million due to additional labor and subcontractor costs based on experience during the development phase.

Finally, the Expendable Launch Vehicle requirements have increased by $15 million for Delta vehicle procurement and launch services.

Question. What are the reasons for the possible slip in the Orbiter 104 production activities underway during 1982?

Answer. At present, there are no plans to slip any OV-104 activities in fiscal year 1982 or to slip the planned delivery date of December 1984. We have, however, stated that for the production funding available, OV-099 and OV-103 are higher priority vehicles than OV-104. If unforeseen problems were to occur, we would shift funds from OV-104 to those vehicles. Currently, OV-104 is on schedule and proceeding according to plan.

Question. What do you see as the major reasons for development of the SRB-X heavy lift launch vehicles? Are DOD requirements a major driver in this activity?

Answer. The present activity on SRB-X is better characterized as a preliminary investigation. We are doing no development at this time. Our present objective is to see if the SRB-X or other Shuttle-derived vehicle concepts might play an advantageous role in a mixed fleet of Shuttles and unmanned launch vehicles. DOD requirements are, of course taken into account in these ongoing mixed fleet studies, though they are no more a "driver" than future NASA and commercial requirements in the long-term fleet composition.

Question. What are your plans for acquisition of the second and third mobile launch platforms? Please tie the schedule for this activity to projected need dates.

Answer. The planned operational readiness date (ORD) for MLP-2 is June 30, 1982 and that for MLP-3 is September 30, 1986. The MLP-2 fabrication effort is essentially complete and activation is on schedule for the June 30, 1982 ORD. MLP-2 is needed at the end of fiscal year 1982 to support the buildup and assembly of the first Shuttle vehicle incorporating OV-099 for STS-6 while the OV-102 Shuttle vehicle for STS-5 is on the launch pad. After OV-102 is reconfigured, there will be two vehicles in flow at KSC almost continuously, which requires two MLPs.

The MLP-3 conversion effort takes three years of industrious fabrication, outfitting and activation time. With the MLP-3 Construction of Facilities budget request planned in fiscal year 1984, the MLP-3 fabrication effort must be started early in fiscal year 1984 and worked continuously to achieve the ORD of September 30, 1986. At that time, the launch rate capability at KSC will be constrained by two MLP's at approximately 15 launches per year, which is equivalent to the planned mission manifest. The third MLP is required for backup at that point and to accommodate any increase in the flight rate.

STATEMENT

of

DR. STANLEY I. WEISS

ASSOCIATE ADMINISTRATOR FOR
SPACE TRANSPORTATION OPERATIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Science, Technology and Space
Committee on Commerce, Science and Transportation
United States Senate

Mr. Chairman and Members of the Subcommittee:

I welcome this opportunity to meet with you to discuss the activities of the Office of Space Transportation Operations (OSTO) and to present our portion of the NASA FY 1983 budget request. Our budget request provides funding for the OSTO program for FY 1983 within the fiscal constraints of the President's economic recovery program.

The major accomplishments of the Office of Space Transportation Operations in 1981 included the delivery of the first Spacelab flight unit to the Kennedy Space Center (KSC), the first operational use of a Spacelab instrument pallet on STS-2 and a perfect record of successful missions using Expendable Launch Vehicles (ELV's) for NASA and reimbursable users. Another first was the use of the McDonnell Douglas Payload Assist Module or PAM-D in launching communications satellites. The OSTA-1 and OSS-1 payloads and the Small Self-Contained Payload (Getaway Special) verification flight unit were delivered to KSC during 1981.

FY 1983 BUDGET REQUEST

INTRODUCTION

This year marks the beginning of the Space Shuttle operational era and for the FY 1983 budget the Office of Space Transportation Operations is requesting $1623.5M, which represents an increase of $912.4M over the amended FY 1982 budget. These funds, together with reimbursements for launch services from non-NASA users, will provide for five operational Shuttle missions in FY 1983 and also support the long-lead procurement of external tanks, solid rocket boosters, spares and other equipment necessary for operational missions in FY 1984 and beyond. In addition, funds are requested for the first Spacelab mission as well as procurement of the second Spacelab flight unit and spares from the European Space Agency. Finally, funds are also required to maintain procurement of Expendable Launch Vehicles (ELV's) to support NASA scientific missions. A large part of the budget increase represents a transfer of funds for launch and mission operations, which almost entirely supported the Orbital Flight Test Program prior to this year, from the Design, Development, Test and Evaluation (DDT&E) elements in the Office of Space Transportation Systems to our operations budget which directly supports all subsequent operational missions.

The FY 1983 request includes two major budget line items for the Office of Space Transportation Operations. The Space Flight Operations budget line item for FY 1983 is $1707.0M of which $1580.7 is the Office of Space Transportation Operations responsibility. This budget line item includes items totaling $126.3M which are defined and supported in the testimony of the Office of Space Transportation Systems. The Expendable Launch Vehicles budget line item for FY 1983 is $42.8M.

Before I present our budget request in more detail, I would like to discuss the responsibilities, business operations and goals of our office.

RESPONSIBILITIES

It is the responsibility of the Office of Space Transportation Operations (OSTO) to manage and coordinate U.S. civil launch capabilities and to cooperate with the Department of Defense (DOD) in providing launch services for national defense missions. OSTO is responsible for the formulation of policies for users of the National Space Transportation System (NSTS) which will consist of the operational fleet of Space Shuttles and a stable of proven Expendable Launch Vehicles (ELV's). These policies include Shuttle and ELV pricing, development of Launch Services Agreements (LSA's) and pricing for the Spacelab and our Small Self-Contained Payload (Getaway Special) program. In addition, we are responsible for marketing the launch services of the NSTS and for the promotion of improvements in the system to reduce costs and meet growth in users' requirements. We are also the NASA office responsible for the Spacelab development performed by the European Space Agency (ESA) and for its operation as an element of the Space Transportation System.

COMMERCIAL USERS

Commercial business operations for our office grew considerably during the past year. New major users included six U.S. commercial and six foreign customers for a total of 41 new reimbursable payloads. An additional 28 new Getaway Special payloads have also been booked for Space Shuttle flights.

During the past year we signed four major Launch Services Agreements; one with Messerschmitt-Boelkow-Blohm (MBB) of West Germany for a Shuttle launch and three ELV Launch Services Agreements with AT&T, Western Union and RCA. Two more Shuttle LSA's are ready for signature with Telesat of Canada and Deutsche Forschungs - und Versuchsanstalt fuer Luft - und Raumfahrt e V (DFVLR) of West Germany, and several ELV LSA's are also ready for signature. The first year LSA's were signed for the Small Self-Contained Payloads (Getaway Specials) was 1981, and this class of payload now accounts for 30 signed agreements with six more ready for signature.

Space transportation is indeed an expanding business and the Space Shuttle is not only an extension of the launch service business we currently operate with Expendable Launch Vehicles, but it extends the services possible both in launch and orbital operations modes. In fact, we are utilizing ELV and Shuttle capabilities and availability in package offerings to communications satellite users. For example, we have recently proposed a combination of a Delta launch in early 1985 and a Shuttle launch in 1986 to satisfy the schedule requirements for the Brazilian National Communications Satellite System (EMBRATEL).

COMPETITION

As with any business, when the market expands, so does the competition. Along with the U.S. and the USSR, the Japanese and European Space Agency now have the capability to provide launch services to Earth orbit. The USSR has launched experimental payloads for India but has not yet actively marketed its capability to provide launch services to reimbursable users. We have agreements with the Japanese which preclude them from providing launch services to third parties with their N and H rockets, developed with NASA assistance, unless they first acquire U.S. concurrence. However, they could sell or lease on-orbit satellite services for communications users. And, of course, competing directly with NASA for reimbursable payloads, the predominantly French Arianespace Company is actively marketing launch services with the ESA-developed Ariane rocket.

Ariane is approximately equivalent in performance to our Atlas-Centaur vehicle and can launch one Atlas-Centaur class or two Delta-class payloads. In addition to pricing their launch services below our ELV's, Arianespace is offering very favorable financing arrangements to prospective payload users -- three U.S. commercial users have already signed launch agreements to fly on that system. We are currently evaluating strategies to compete effectively with the Ariane, with both price and other capabilities of our Shuttle/ELV fleet being considerations. Our office is, of course, obligated to establish new prices for Shuttle launches beyond 1985 (governed by previously established policy), and we expect these to be competitive.

DOD RELATIONS

We are also in the business of providing launch services for DOD and are increasing our cooperative activities with them to support their mission requirements. These include payload integration and mission operations planning for several DOD payloads plus facility and procedural modifications at the Johnson Space Center (JSC) and the Kennedy Space Center (KSC) to provide for secure DOD payloads. The DOD is responsible for the development, activation and future operation of the Space Shuttle launch complex at Vandenberg Air Force Base in California. This capability is scheduled to be available in late 1985 for both DOD and NASA launches. We are also currently involved in the negotiation of a Memorandum of Agreement (MOA) with DOD which updates the STS reimbursement policy for Space Shuttle launch and associated services. Other cooperative efforts include NASA's utilization of the Air Force to supply the Inertial Upper Stage (IUS) for the Tracking and Data Relay Satellite (TDRS) and NASA planetary payloads and NASA's reliance on Air Force range support at KSC and the Western Space and Missile Center. DOD's recent decision to use elements of the Spacelab for certain orbital experiment programs and intention to fly several small payloads in our Getaway Special canisters on future Space Shuttle missions provide further evidence of the benefits of the Shuttle to national security needs.

GOALS

The Office of Space Transportation Operations' major goal is to maintain the U.S. position as a world leader in space launch and orbital service activities through effective operation of the National Space Transportation System. Specifically, we will initiate operational Space Shuttle missions with the flight of STS-5 early in FY 1983 and plan to conduct 28 operational Shuttle missions through 1985 following completion of the four Orbital Flight Tests this year. In response to increasing foreign competition for reimbursable launch services, we will pursue a Shuttle cost-per-flight reduction plan to permit competitive pricing while still recovering STS operational costs for the government. We will also be increasing our activities to stimulate the use of space as a resource and, therefore, broaden our market.

I would now like to discuss our budget request for FY 1983 and explain the details about anticipated costs in major areas of our program.

SPACE FLIGHT OPERATIONS

The FY 1983 request for the OSTO portion of Space Flight Operations of $1580.7M includes $1414.1M for STS Operations, $53.4M for STS Operations Capability Development and $113.2M for Spacelab.

SPACE TRANSPORTATION SYSTEM OPERATIONS

Space Transportation System (STS) Operations covers activities in Shuttle Operations, Spacelab Operations, Upper Stages Operations and Payload Support Operations. Funding for STS Operations will support a schedule of five launches in FY 1983, 10 launches in FY 1984 and 13 launches in FY 1985. Our FY 1983 budget request for STS Operations of $1414.1M, includes $1316.6M for Shuttle Operations, $63.0M for Upper Stages Operations and $34.5M for Payload Support Operations.

The successful Space Shuttle test flights of STS-1 and STS-2 have demonstrated the technical feasibility of our reusable Space Transportation System. With two remaining orbital flight test missions scheduled in 1982, we are on the threshold of routine manned access to space. Current plans are to fly two NASA payloads and eight reimbursable commercial payloads on five Space Shuttle flights in FY 1983. As we initiate the operational Space Shuttle phase, we will continue to develop our operations capability to support an increasing rate of missions. NASA's preparations for operating the STS on a full scale include all of the activities required to plan, schedule and conduct Space Shuttle operational missions. They include such elements as facilities, flight hardware, personnel, plans and operating procedures. In addition, we must provide and prepare ground and flight equipment, ground and flight crews, flight planning and mission control functions, computer support, communications links, logistics support, scheduling, user interface integration and overall management of the system.

In conjunction with the Office of Space Transportation Systems we are funding several activities designed to promote efficiency and economy in operating the Space Transportation System as we begin the operational period. The most significant of these activities is the NASA and contractor effort to improve the producibility of external tanks and solid rocket boosters, which are limiting factors in the capability of the Shuttle to support the level of 24 flights per year in FY 1988.

Another significant activity for which funding is included in the FY 1983 request is the on-orbit retrieval and repair of the disabled Solar Maximum Mission Satellite using the Space Shuttle in FY 1984. Our primary objective for this mission would be to conduct a technical demonstration of the Space Shuttle capability for on-orbit rendezvous, retrieval, repair, checkout and redeployment of a free-flyer spacecraft. In this mission two astronauts would leave the Orbiter in spacesuits to replace the attitude control system module on the spacecraft and perform other repairs. We consider this mission to be a vital opportunity to provide early demonstration of Space Shuttle rendezvous and retrieval capabilities which will be necessary for a variety of civil and national security missions, including the NASA Space Telescope.

Preparations for Shuttle Operations continue to require the largest portion of the OSTO budget. The $1316.6M requested will be used to support the first five operational Shuttle missions, procurement of long-lead equipment for future operational missions and sustaining engineering. These activities include mission planning and flight operations, orbiter launch and landing processing, cargo processing and payload integration and procurement of external tanks, solid rocket boosters and spare equipment. During FY 1983 we will have 18 external tanks in production with five delivered to KSC and nine solid rocket booster flight sets in production with five sets delivered to KSC.

FY 1983 funding for Upper Stages Operations is required for the production, delivery and operation of the Air Force Inertial Upper Stage (IUS). During 1983 we will use two IUS's to carry two Tracking and Data Relay Satellites (TDRS's) from the Shuttle to geosynchronous orbit.

FY 1983 funding for Payload Operations Support provides for continuing integration and analysis activities relating to NASA payloads scheduled for launch through FY 1987.

STS OPERATIONS CAPABILITY DEVELOPMENT

STS Operations Capability Development (OCD) includes Multi-Mission and Payload Support Equipment, Mission Control Center upgrading (MCC II), Payload and Operations Support and STS Operations Effectiveness. Our FY 1983 budget request for STS Operations Capability Development is $53.4M.

Our funding for Multi-Mission and Payload Support Equipment will be used to continue development, test and installation of a variety of flight and ground hardware which will be developed into a standard, reusable inventory of equipment to be used with a wide variety of payloads.

Our funding request for the continuation of Mission Control Center upgrading (MCC II) will be used to reconfigure the MCC at the Johnson Space Center with new equipment and software to support the requirements of the STS operational flight schedule. The DOD is also providing funds to install required modifications to support their unique mission requirements, including security.

Our funding request for Payload and Operations Support will be used for the development and activity of the Payload Operations Control Center (POCC) at the Johnson Space Center which will support NASA Spacelab missions in conjunction with the Mission Control Center. The funding for FY 1983 will be primarily for the Spacelab-1 and OSTA-2 missions.

FY 1983 funding for STS Operations Effectiveness will be used for initiating improvements in STS vehicle hardware, vehicle turnaround and cargo processing, mission operations and system software automation. This funding will also support Systems Planning and Effectiveness studies to develop marketing strategies for assuring maximum utilization of the National Space Transportation System (NSTS) while reducing the cost and complexity of STS Operations. It will also be applied to evaluating possible scenarios for the future institutionalization of the Space Transportation System.

SPACELAB

The Spacelab is a key element of the Space Transportation System. It is a versatile general purpose laboratory designed for manned and unmanned operation inside the Orbiter payload bay. It includes a pressurized module with a comfortable "shirt-sleeve" environment plus support pallets which carry experiments requiring direct exposure to space. Our FY 1983 budget request for Spacelab is $113.2M.

The first Spacelab flight unit is currently at the Kennedy Space Center (KSC) for the initiation of checkout and testing to support the first Spacelab mission in FY 1983. The engineering model (delivered December 1980) and three engineering model pallets are also being used for preflight tests and evaluations. We are looking forward to the first Spacelab mission in FY 1983 and are under contract to procure the second flight unit from ESA. Also, we are continuing to promote use of the Spacelab by reimbursable users and are currently scheduling Spacelab missions for the Germans (Spacelab D1 and D4) and payloads for the French and Japanese.

OSTA-1 was the first scientific payload to be flown on an ESA-developed Spacelab pallet in the Space Shuttle. The OSTA-1 mission demonstrated that the Orbiter is an excellent platform for conducting scientific investigations in Earth orbit. Although the flight of STS-2 was shortened from five to two and one half days, NASA scientists received high quality data from the Shuttle Imaging Radar and five other experiments, achieving 90 percent of the primary goals for this mission.

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Most Spacelab funding will be used to continue the procurement of the second flight unit and spares for which we have contracted with the European Space Agency (ESA). It will also support the first Spacelab mission in late FY 1983 with completion of the first crew transfer tunnel and the Spacelab simulator which supports crew training at JSC for their mission. Funding will also be required for analytical and physical integration of Spacelab-1 as well as the continuation of sustaining engineering, logistics and testing efforts. Although the design of the ESA-developed Spacelab flight unit and ground support hardware is well-defined, some FY 1983 funding will be necessary to perform minor modifications to the Spacelab flight ground support equipment hardware, facilities and follow-on hardware at KSC to assure proper interfacing, compatibility and reliability. In addition, funds will be required for the Spacelab integration contractor to support preparations for the first flight, to test the new crew transfer tunnel, to maintain operational software using the Software Development Facility at the Marshall Space Flight Center, and to continue integration and checkout of the flight unit hardware and software at KSC.

EXPENDABLE LAUNCH VEHICLES

NASA's Expendable Launch Vehicle fleet continues to provide the largest number of U.S. launches and will total 13 in 1982. While NASA will fly Atlas-Centaur, Delta and Scout missions, all but two will be fully reimbursable by the commercial, foreign and other government agency users. Our FY 1983 request for this budget line is $42.8M.

The OSTO has maintained an active Expendable Launch Vehicle program to meet the space transportation demand for other U.S. government agencies, commercial and foreign users and the DOD, as well as NASA's own payloads not scheduled for launch on the Space Shuttle. During 1981, we successfully launched two NASA scientific and nine reimbursable payloads on NASA ELV's. The McDonnell Douglas Payload Assist Module (PAM-D) was successfully used for launching one RCA and two SBS communications satellites. A version of the PAM-D, called the Spinning Solid Upper Stage (SSUS-D), has been developed to be used with the Space Shuttle to launch U.S. and foreign commercial communications satellites. We have already scheduled six NASA and 50 reimbursable payloads to be launched on NASA ELV's through the end of FY 1985 to supplement the launch capability of the STS. We are continuing to maintain Delta rocket launch capability as a backup to the Space Shuttle and to meet heavy user launch demands as required during the build up of the STS to full operational capability.

Our FY 1983 funding for Expendable Launch Vehicles will be used primarily for the Delta launch vehicle to support NASA missions scheduled for launch in this and subsequent years. These missions include the Infrared Astronomy Satellite and Landsat-D[1] to be launched from the Western Space and Missile Center and the Active Magnetospheric Particle Tracer Explorer to be launched from the Eastern Space and Missile Center. The funding is required for the continuation of hardware production, technical and engineering support to sustain vehicle test and checkout and launch operations at both sites.

The major funding requirements for the ELV program are not reflected in this request. That funding comes from reimbursable users of NASA ELV launch services. These include DOD for communications and navigation systems, NOAA for weather satellites and a variety of domestic and international communications activities.

SUMMARY

We are planning a very ambitious program for FY 1983 with the initiation of operational Space Shuttle missions, the first flight of the Spacelab and the continuation of ELV operations. Although there is risk, I firmly believe we can achieve our goals with the requested level of funding.

OFFICE OF SPACE TRANSPORTATION OPERATIONS

SPACE TRANSPORTATION SYSTEM MANIFEST SUMMARY

	NUMBER OF LAUNCHES				
	82	83	84	85	86
SPACE SHUTTLE					
COMMERCIAL/FOREIGN	0	2	3	4	5
DOD	1	0	2	4*	6
NASA	2	3	5	5	6
SUBTOTAL	3	5	10	13	17
EXPENDABLE LAUNCH VEHICLES					
COMMERCIAL/FOREIGN	9	6	8	5	5
DOD	1	5	5	7	1
NASA (INCLUDE NOAA)	3	6	1	4	—
SUBTOTAL	13	17	14	16	6
TOTAL	**16**	**22**	**24**	**29**	**23**

* PLUS POSSIBLE BACKUP MISSION

FIGURE 1

OFFICE OF SPACE TRANSPORTATION OPERATIONS

STS CAPABILITY DEMONSTRATION MILESTONES

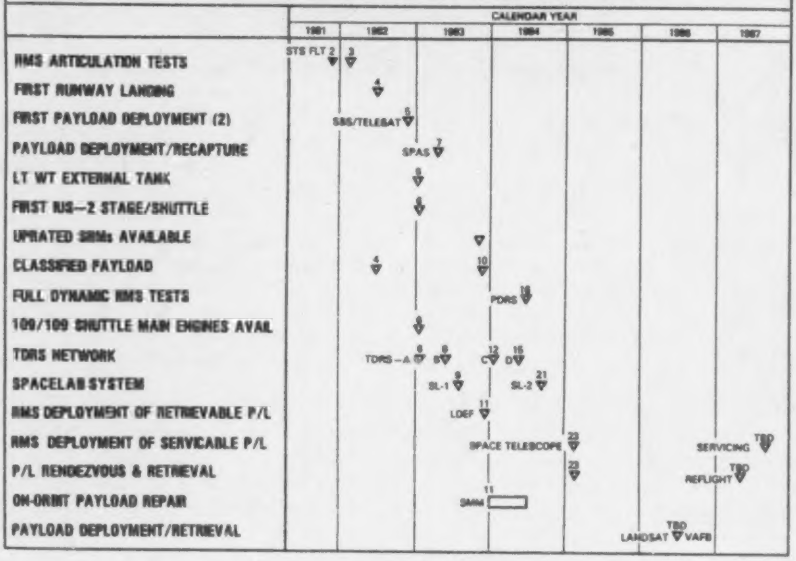

FIGURE 2

OFFICE OF SPACE TRANSPORTATION OPERATIONS

FY 1983 BUDGET

SUMMARY OF REQUIREMENTS

(DOLLARS IN MILLIONS)

	FY 1982	FY 1983
• SPACE SHUTTLE	2163.0	1718.0
• SPACE FLIGHT OPERATIONS	895.9	1707.0
• DTMS/ENGINEERING & TECHNICAL BASE	184.0	82.4
• ADVANCED PROGRAMS	8.8	11.9
• STS OPERATIONS CAPABILITY DEVELOPMENT	79.3	85.4
• MMPSE, MCC II, PI, POCC, OPS EFF	56.1	53.4
• UPPER STAGES DEVELOPMENT	23.2	32.0
• SPACELAB	100.8	113.2
• STS OPERATIONS	523.0	1414.1
• SHUTTLE	435.3	1316.6
• UPPER STAGES	67.5	63.0
• PAYLOAD SPT	20.2	34.5
• EXPENDABLE LAUNCH VEHICLES	31.2	42.8
TOTAL	3090.1	3467.8

FIGURE 3

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR SCHMITT AND ANSWERS THERETO

STS OPERATIONS

Question. Is NASA actively marketing the use of the Shuttle commercially? Is so, how is this being done?

Answer. Traditionally, the "marketing" of NASA's launch capabilities was performed primarily by the launch vehicle and spacecraft contractors. However, with the advent of the Shuttle, NASA recognized that a NASA-conducted marketing effort would be required in order to achieve full utilization of the Shuttle and, more recently, to respond to the competition from Ariane. Toward that end, NASA has begun a vigorous effort to identify new and repeat customers with traditional uses of launch services (e.g., telecommunications satellites) and new customers with new uses of launch and orbital services (e.g., Spacelab and Materials Processing). In the latter category, NASA has implemented joint endeavors to stimulate U.S. industry to pursue the commercial manufacturing possibilities of the Shuttle.

NASA is currently developing a marketing strategy and program to more formally define activities in this area.

Question. What new initiatives do you anticipate over the next few years to standardize both Shuttle systems and Shuttle operations for reducing the costs for routine access to space?

Answer. New initiatives which are planned to reduce costs in the operations era by standardization are: standardizing ascent and descent profiles, payload/orbiter interfaces, and flight and ground software. In addition, we are investigating a concept which will provide autonomous payload command and data services thereby eliminating future interaction between payload and orbiter systems and permitting greater standardization of the orbiter software.

Question. When do you expect final recommendations to be made regarding arrangements for operation of the Shuttle? What is the extent of activity in this area? What is the plan to evaluate the proposal from the Space Transportation Company?

Answer. The Office of Science and Technology Policy (OSTP) has been directed by the President to conduct a National Space Policy Study. One of the principal issues is to determine the best institutional options for the operation of the Space Transportation System. NASA formed a study team in early February that has been working on this issue extensively since that time. DOD formed a study team in mid-March and is currently evaluating this same issue. In addition, an Interagency Task Team was established by the OSTP and charied by NASA. The Team is composed of representatives from NASA, DOD, the Departments of State and Commerce, the Arms Control and Disarmament Agency, Office of the Director of Central Intelligence, and the Office of Management and Budget. This group will make recommendations to the OSTP Working Group and Steering Group this summer.

The Space Transportation Company has formally submitted a proposal for purchasing an orbiter which would be operated by NASA. The Agency is reviewing the proposal which involves many complex facets, and an evaluation will be completed within the next few months.

Senator **SCHMITT**. Our next witness is Mr. Edward C. Aldridge, Under Secretary, U.S. Air Force. And he will be accompanied by Brigadier General Randolph and Dr. Charles Cook. Brigadier General Randolph is Director of Space Systems Command, Control and Communications, and Dr. Cook is the Deputy Assistant Secretary for Space Plans and Policy.

It is my understanding, Mr. Aldridge, that you will have a statement and then we can proceed with questions.

If you could summarize so that we're within 10 minutes, your entire statement will be included in the record.

STATEMENT OF EDWARD C. ALDRIDGE, JR., UNDER SECRETARY, U.S. AIR FORCE, ACCOMPANIED BY BRIG. GEN. BERNARD P. RANDOLPH, DIRECTOR OF SPACE SYSTEMS AND COMMAND, CONTROL AND COMMUNICATIONS, DEPUTY CHIEF OF STAFF FOR RESEARCH, DEVELOPMENT, AND ACQUISITION, U.S. AIR FORCE; AND DR. CHARLES COOK, DEPUTY ASSISTANT SECRETARY OF THE AIR FORCE FOR SPACE PLANS AND POLICY

Mr. Aldridge. Yes, sir. I thank you, Mr. Chairman, for the opportunity to appear before this committee today to discuss the Air Force's participation in and the activities of the U.S. space program. You have already introduced Dr. Cook and General Randolph, who will be accompanying me and who can answer any questions at the followup.

I have a prepared statement which I would submit for the record for you. It does address the current status of the Air Force role and responsibility in the Shuttle program and the related activities, such as the development of the inertial upper stage and construction facilities at Vandenberg.

Let me assure you from the beginning that the DOD and the Air Force are fully committed to the utilization of the Shuttle capability. This program is a national asset and by mutual agreement in 1977, the Air Force is to provide and operate the Vandenberg Air Force Base facility, to develop the inertial upper stage for national users, and to integrate DOD payloads on the Shuttle. NASA is to develop and procure the Shuttle and to operate the Kennedy facility.

This agreement was reiterated in 1980, at which time it was considered that the arrangement was a reasonable sharing of responsibility and costs for all users.

I would now like to touch on several points of which I believe this committee is concerned. These points deal with the increasing importance which the Air Force and the Department of Defense attribute to the military uses of space systems.

We have heard many assertions that there is no plan for the military use of space and space activities, and that they suffer from duplication and fragmentation of effort. In fact, I have even heard the statement that the Air Force plans for space are in shambles. I'd like to address these assertions directly.

First, let me state, to the contrary, that the DOD and the Air Force have solid plans for the continued expansion of space capabilities and the exploitation of space for military purposes. A planning process really cowers three periods. The first period is within the next couple of years. During this period, our space programs are well established. All we can change or influence, in those short periods of time, are the operational procedures and launch satellites to replace failures or to replace those ending their useful life.

The next period is the 1985 to 1988 period. During this period, we can procure satellites currently in production or nearing the end of their development. We can make minor modifications to existing programs. We can complete ongoing projects. And we can influence the direction of our technology programs. These programs and necessary funds are now included in the 5-year defense program.

The next period is within the 1990 to the year 2000 period. This is a period of greatest flexibility of planning and of the greatest uncertainty. Depending on the pace of our technology efforts, we can make the greatest change in our capability to exploit space. With the exception of our technology efforts, the funding to procure such new capabilities would fall beyond our 5-year program.

Included in our space plans for all three periods are several goals. First, we need to expand our military capabilities in space. This is inevitable, due to the miltiary and economic advantages of space surveillance, communications, and navigation.

Second, we need to develop a confident capability to obtain free access to space. This is being acquired through enhancing our capability for reliable and responsive launch systems and protection of our satellites from those who would deny us free access.

We need to pursue a vigorous R. & D. program to give us the future military options in space, such as an antisatellite system to deny access to space to those satellites we considered harmful to our interest and potentially, military weapons in space for protection of satellites or defense of our forces.

Since last year, 1981, we have had eight formal studies, master plans, requirement studies, and policy studies to set forth a DOD course for military utilization of space. As a result of these studies and other decision processes, we are proceeding with the following plan for space operations. We will make our space systems, the satellites, and the ground processing stations, more survivable to attack. Specific programs are funded to accomplish this capability. We have programs to improve, through evolutionary changes, the surveillance, communication, and navigation capabilities of our space systems. We're improving the robustness of our space system network by removing single nodes, procuring backup satellites, and removing dependency on overseas ground stations.

We are relying on the Shuttle to be the primary military satellite launch system. The Air Force will launch all DOD payloads and operate all satellites that have multiple users. We are improving the use of national systems in support of our military commanders. We have funded programs to improve the quality, timeliness, and quantity of information available to tactical commanders. Better information on our adversary will offset, to some extent, numerical inferiority in weapons systems.

Let me assure you that these are not just words. These are facts backed up by the fact that the Air Force funding of about $3 billion a year on space and space activities is for real.

Plans for our space capabilities in the future are more uncertain. There are two principal issues that affect our future direction. One is the pace of our technology programs, which could lead to weapons in space. And, second, our launch strategy after transition to an operational Shuttle; that is, do we need more orbiters or should we pursue a mixed-fleet strategy?

This latter point is one worthy of specific comment. The DOD can satisfy its mission needs with a current buy of four orbiters. However, unanticipated delays in delivery, problems in turnaround after flight, or orbiter attrition, could force DOD and the Air Force to exercise its priority over noncritical Shuttle missions to meet critical launch needs and schedules.

It is for these reasons that we believe it is prudent to continue with additional Orbiter procurements to insure the viability of the Shuttle for all users. To do otherwise would force us into a mixed fleet strategy for DOD launches to reduce the demands on the limited orbiter fleet.

These two issues are currently being addressed in the Keyworth study, the President's scientific adviser on national space policy, in which the DOD and the Air Force are participants.

Regarding the issue of space management fragmentation, let me state, to the contrary, that there is no unwarranted division of labor in the space arena. Let me support that statement with the following points.

There is only one Air Force organization tasked with acquiring Air Force satellites. It is the Air Force Systems Command Space Division in Los Angeles, Calif. The Space Division, by agreement, also acquires Navy satellites. The Space Division is also tasked with launching all Department of Defense payloads and providing all onorbit support for common user systems; that is, systems that support a multiplicity of users.

Only in the operation of spacecraft which have unique military functions in support of a specific military command could one contend a fragmentation of effort. This contention, however, is also in error. Space, like the oceans and the air space around us, is a medium in which to conduct operations which support some basic military mission. Space is not a military mission in itself. Once the Air Force space system is acquired and launched by Space Division, the operational task is turned over to the using combatant command. This is analogous to an aircraft developed and acquired by the Aeronautical Systems Division of the Air Force Systems Command being turned over to the Stategic Air Command, the Tactical Air Command, or the Military Airlift Command, and employed according to specific mission needs of the user command.

However, at the same time, we recognize that space systems have many unique characteristics and uses which demand that we be alert to ways to improve the effectiveness of these limited expensive assets and enhance their war-fighting potential in a conflict.

For instance, for information to be provided to several commanders, there may be some benefits to integrating the responsibilities of space systems acquisition, launch and operations into a single space service, and providing the resulting product to global using commands.

To address such questions, the Office of the President, DOD, and the Air Force are actively investigating new management schemes for space operations. The Keyworth study on national space policy is analyzing space system management. There is an internal DOD study on military space operations addressing space management responsibilities. And there is an internal Air Force study on space system management options, of which a joint space command is one consideration.

I believe by the end of this year we will be able to specify an evolutionary plan for the management and operation of the Shuttle and U.S. military space systems.

Mr. Chairman, with your indulgence, I'd like to briefly address two issues that may have created a greal deal of confusion and misunderstanding in the past few months. The first is the issue of the IUS versus Centaur, and the second is the consolidated space operations center.

As a result of the NASA decision not to use the long-tank Centaur for the Galileo and solar polar missions, the Air Force and NASA undertook a joint study to see if a short-body Centaur was a viable candidate to satisfy NASA and DOD missions in lieu of continuing IUS production beyond the nine IUS vehicles in the current full-scale engineering development contract.

While performance and unit cost advantages of the Centaur over IUS appeared attractive, other more significant factors indicated that such a move at this time would be high risk. These factors include the following. The near-term cost to pay for continuing the IUS production while simultaneously developing Centaur were too high and would not be competitive in the DOD or NASA budget with other high-priority programs. Terminating the IUS production to partially pay for Centaur would fit in the NASA and DOD budget levels, but would require some significant schedule and program adjustments to transition to the Centaur after termination of the IUS program after full-scale engineering development.

These adjustments would include delays in the launch of a critical DOD payload and a TDRSS satellite by as much as a year and delay the Galileo mission from April to late 1985. It would require procurement of additional Transtages and a Titan III 34-D booster to fill DOD launch requirements, and require modification to the Shuttle to accommodate the cryogenic Centaur propellant.

But most importantly, it presented unacceptable cost uncertainty and schedule risk to DOD. This risk was the result of our inability to define the payload environment and modification requirements to adapt very sensitive DOD payloads to the Centaur prior to committing to an accelerated program to meet the 1985 Galileo mission launch.

In summary, while the long-term performance and potential cost savings using Centaur appeared attractive, the near-term schedule and cost risks were judged to be unacceptable to the Department of Defense and the Air Force.

Mr. Chairman, I'd like to, due to time, defer the CSOC question until question time, but let me just make points in conclusion.

The Air Force has aggressive plans and programs for exploiting the unique military advantages of space and we have an effective management structure to carry out these goals. There are national and internal study activities currently underway to provide guidance and direction for future national capabilities in space. To implement these plans and programs, we will need continued congressional support on insuring the viability of the Shuttle program, continued support for space system technology and procurement programs, and continued support for the construction of the consolidated space operations center in Colorado Springs.

Thank you, Mr. Chairman, and we are available to answer any questions you may have.

Senator SCHMITT. Thank you, Mr. Secretary. I don't think that there is any question that you've made some progress in the last year or so in response, or at least maybe not in response to the criticisms that some have made. But you're still faced with the absence of any space command that you are considering as one option. You're faced with the Secretary of Defense, in his own mind, at least, indicating right after the launch, successful launch and recovery of STS-1, that Shuttle was not a high priority. And even though you describe many of the space activities that the Air Force is undertaking, or plans to undertake, you are still faced with the general conception, apparently within the DOD, that Shuttle and other space capabilities are merely there to support their existing mission responsibilities.

The problem that I have and that others have is that there does not seem to be a recognition of what the future may hold and what the potential of the space mission, of the space environment, combined with missions, offers for guaranteeing free access to space, not only for our defense establishment, but for our civilian and commercial establishment, and creating an integrated manned and unmanned space overlay system that can offer a significantly different concept for keeping the peace.

I guess that's what disturbs us, is that you've got a whole bunch of different people doing a bunch of different things. However integrated they may be, there doesn't seem to be any conceptual framework of why they're doing it other than to carry out their existing mission responsibilities.

Mr. ALDRIDGE. Sir, can I address that?

Senator SCHMITT. Surely.

Mr. ALDRIDGE. I think, as far as the commanders, the tactical commanders, who have the responsibility for the defense of the United States, that is precisely their mission, and that should be their mission—how can they best carry out their mission? And they will use whatever medium and whatever systems they can to accomplish that task.

I think they look upon space perhaps with renewed interest in the last several years because we are now getting to the point where, all of a sudden, the Shuttle is a reality. Several years ago, it was a research and development program. It is now an operational program.

I think we're beginning to see new and rejeuvenated interest in how can they exploit this unique capability? We are looking at ways to launch larger payloads, more sophisticated payloads in space, and I think that that is on the right track.

I think, as General Abrahamson talked about, there is a culture change that has to occur to realize the full potential, I think that that is, in fact, occurring. I think the realization that, hey, our management structure for space operations needed to change, and all that was a result of the catalyst called the Shuttle program. I think it's something that's right. I think we have time to do that. I think we are taking the proper steps to do that. We have the funding necessary to carry out those programs. And I think we have a fairly aggressive and a program that is building in momentum. Hopefully, within the next several years, we will have appreciation of that by creating some type of a command for space.

But I still think it's important that the military commanders who have specific war-fighting functions look for all ways to carry out their mission in the most effective way. I have used the term, "space being the ultimate high ground." I think that you have used that same term. I didn't try to copy you in that sense, but I think it's clearly correct. I think that space has some very unique military advantages, both militarily, as well as economic advantages. And we're trying to carry those out.

Senator SCHMITT. Well, I see a former NASA official, a good friend of mine, in the front row, who some years ago, I believe, said at a conference at Goddard, in response to a statement by our good friend, Gene Schumacher, that NASA was like a large, friendly whale on the beach, in that you push and push and push and then you stand back to rest, and even the dent you made disappears.

It was said by the NASA official, "Well, Gene, you ought to try pushing it from the inside."

So I'm sympathetic to what you and the colonels and the one-stars and two-stars may be trying to do. But those of us who are pushing from the outside still, every once in a while, stand back and we see the dents disappear. The Air Force and DOD is very much a large, friendly whale, at least I hope they are.

And it is very disturbing in this particular budget cycle to see a $250 billion plus defense budget come down the line with tremendously important funding contained within it, and then to see NASA's budget, with also important funding, but for a few tens, in some cases, a few hundreds of millions of dollars in others, losing the opportunity to develop national capabilities that are as important for our national security as much of what the Department of Defense is doing. And we just can't seem to cross correlate.

The aeronautics program is taking it in the ear in this budget. The development of a high energy upper stage, for whatever rationale you may give, is a national need. And to say that we can't adapt it both to civilian and to military use, I think is being unrealistic. To see the other things in space applications and planetary technology development and so forth, all of which feed into a total national security capability, as well as scientific capability, lost in this year's budget, while the Defense Department says that they still are just going to carry out their missions, is a very disturbing trend.

I think your heart is in the right place, but I, personally, don't see that your money is in the right place.

Mr. ALDRIDGE. Can I address that? The Defense Department, at $250 billion, has one heck of a lot more missions to accomplish than NASA has. When you look at the space part of the Air Force part of space systems, we're talking about $3 billion. So let's compare $6.6 billion minus what would be in the aeronautics part, a $3 billion part of the Air Force which can be applied to space applications.

Senator SCHMITT. No, I'm not going to let you do that.

Mr. ALDRIDGE. I didn't think you would.

Senator SCHMITT. The capability that is being provided by these technologies goes way beyond the Air Force. It goes ultimately to whether or not we are going to be able to use this new environment to preserve the peace on Earth, and to expand our civilization into a new environment, the first in many centuries that is available through technology to mankind.

If we do not do that, and if we do not have free access to that environment, which could very well be denied us, the way things are going today, then we will be finished as a civilization.

So it's not comparing a $3 billion Air Force budget with a $6½ billion NASA budget. Those are incidental to the total problem that we are about and the total problem that we must solve.

Mr. **ALDRIDGE**. Back in 1977, when the agreement was first made, there was a conscious decision that there was a fair sharing of the responsibilities on NASA to develop the Shuttle program and the Air Force to procure, construct and operate the Vandenberg facility, coupled with the development of an IUS. And I think, in fact, I have just made the statement that we fully support the need to continue the Shuttle and orbiter procurement. We felt that that was part of the original agreement for NASA to buy orbiters for a multiplicity of users, not just for the Department of Defense.

I think the Department of Defense has, in fact, faced up to paying for any particular item that is unique to the Department of Defense. That's why we felt that the development of the inertial upper stage at that time should be part of the DOD budget, because that was the primary user for achieving geosynchronous altitudes.

At this time, we would continue to support any cost of the STS which is unique to the Department of Defense—unique to the Department of Defense. And I think that the issue of the filament wound case, the issue of the recovery mechanism, the refurbishment function, is not unique to the Department of Defense. It has a multiplicity of users. The fifth orbiter is not unique. It was part of the original national program by which there was a general agreement that there would be a sharing and the fifth orbiter would not be used just for Department of Defense. It would be used for everyone.

So based on that kind of agreement——

Senator **SCHMITT**. That's great. That's a great technical argument and a lot of us weren't party to that fair share agreement, so to speak. And what we're concerned about now is whether you're going to have it, not whether it's unique or not, but whether you're going to have it. I can't guarantee you right now that there's going to be a fifth orbiter. The fact is, if I had to take bets, if things continue as they're going, there's not going to be, because of the kind of attitude that's represented here by the Department of Defense.

If I had to predict, I'd say that we're going to lose the aircraft market in this world over the next 10 years if we continue to have the attitude that we have toward aeronautics development. If I had to predict, we're not going to develop any new generation of high reliability, deep space robotics that feed, as you know, directly into what we're trying to do in Earth orbit for our national defense.

That's what the NASA budget is contributing. And nobody in the Department of Defense, that I can see, is willing to recognize that. They're saying, well, if it's not developed, so be it. We'll go off and fly our expendable launch boosters and we'll get everything we need.

There just may not be a fifth orbiter. And if there's not a fifth orbiter, before long, there probably won't be a fourth orbiter.

Mr. **ALDRIDGE**. That's correct.

Senator **Schmitt**. Either because we don't build it or we cancel it. And then where are we? Then we have no civilian program at all, because the defense-related stuff is going to take, appropriately, the first priority. The whole thing starts to fall apart. And right now, it appears that it's going to fall apart because of this attitude that the Department of Defense should only be contributing to those things in which it has a significant, major, direct interest. The availability of a Shuttle fleet, to serve its purposes, as well as other national interests, the availability of a thrust augmentation to serve its purposes, as well as other national interests, and the availability of a high energy upper stage, to serve its purposes, as well as other national interests, are the items at issue here.

Mr. **Aldridge**. Sir, that was the agreement that was reached in 1977 and reiterated again in 1980.

Senator **Schmitt**. Have there never been any agreements that have been wrong between agencies?

Mr. **Aldridge**. I'm sure there probably will be, continue to be problems.

Senator **Schmitt**. We'll recess for a few moments while I vote. [Brief recess.]

Senator **Schmitt**. The hearing will come back to order.

Mr. Secretary, I think that you and I have similar long-term goals and it's going to take us awhile to reach agreement on just what they are and how to get there. And we'll continue the dialog, I hope, and maybe the whale will either start to move itself off the beach or the ocean will rise. Who knows?

Mr. **Aldridge**. Sir, don't stop pushing on the whale.

Sir, just as a side note, I'd like to introduce a person who is here with us. He is the new director of space operations from the Department of the Air Force, Gen. John Storrie, who is back here.

Senator **Schmitt**. General Storrie and I have had a chance to talk before. I've welcomed him before and I'm happy to have him onboard.

Mr. **Aldridge**. Another indication of our slow movement in the right direction.

Senator **Schmitt**. Well, it could be, as I look at various versions of organization charts that have to do with space, one of them labeled, "Shuttle Applications Market Trail," I don't know whether that was reference to the Snail or not.

Let's get specific. Would you agree that it would cost approximately $1 billion to develop the new high-energy upper stage that you suggested be developed in your memo.

Mr. **Aldridge**. If we started from scratch with a brandnew program, without any consideration for existing technology or existing programs, yes, sir. That does not preclude, however, the possibility that we could, in fact, use a derivative or major parts of an existing stage and could conceivably cut the cost by a significant margin.

The purpose of the fiscal year 1982 $4 million being reprogramed by the Air Force is to come up with the requirements for such a stage and what might be the technology applications for a new higher energy upper stage.

Senator **Schmitt**. Why are you studying that again? We have a report signed by the Air Force and NASA that's less than 6 months old, and let me quote a paragraph from it. The report summarizes, and this is the cover letter signed by Secretary Orr and Hans Mark:

> The report summarizes the status and general characteristics of upper stages, nonuse or in development, as well as new vehicles possibilities examined during the study. It then discusses upper stage requirements for both civil and DOD missions, categorized generally in the near-term, mid-term, and far-term, dates given. Finally, it examines the technical schedule and cost impact of alternative ways in which these requirements could be met and reaches a number of conclusions and recommendations.

The principal recommendation, as I read yesterday, is: "In order to satisfy the national mission requirement needs of both the DOD and NASA, the Air Force should continue development and production of the IUS and NASA should develop the Centaur."

Mr. ALDRIDGE. There is a third recommendation in there, sir, in that we should look for the development of a high-energy upper stage for the late 1980's. That's part of the study. The differences between now and then were that NASA made a decision because of its priorities and its funding to not proceed with the long-tank Centaur. The Air Force is continuing to proceed with the IUS in the near term and what we decided to do based upon the more recent studies, the demand for a higher energy upper stage became more apparent to us and we have gone back, found the resources to reprogram funds in 1982 to begin the higher energy upper stage perhaps a little faster than we had first anticipated.

Senator SCHMITT. Your memorandum discusses the need for a higher energy upper stage with an 87-IOC. I don't think that you can make it from here to there. Not with $4 million this year.

Mr. ALDRIDGE. We believe we can make late 1987. We'll try to make late 1987.

Senator SCHMITT. Is there any contractor who will stand up and support that?

Mr. ALDRIDGE. The Centaur was going to be developed and delivered within 33 months.

Senator SCHMITT. Well, you're not saying that's what you're going to develop.

Mr. ALDRIDGE. Sir, the question was could we develop it by 1987.

Senator SCHMITT. A Shuttle-compatible vehicle.

Mr. ALDRIDGE. The answer is: "Yes, sir, we could develop it by 1987." If we could proceed with the funding starting in 1982, if the Centaur was the right answer for the 1987 period, I believe we could certainly make it by 1987. There may be other solutions.

Senator SCHMITT. Well, why don't we just let NASA proceed? It could be both short and long—there's only a $45 million differential between developing both versions.

Mr. ALDRIDGE. Yes, sir

Senator SCHMITT. You just don't believe that it will be useful to the Air Force?

Mr. ALDRIDGE. No, sir, that's not what I said. I think the Centaur would be absolutely useful to the Air Force. The problems that we had, and realizing—let's back up. That study that you quoted, the requirements, the summary was that NASA would develop the long-tank Centaur for its missions and the Air Force would develop the IUS for its missions.

NASA made a decision to not proceed with the long-tank Centaur and we decided to go back and relook at the question of whether or not a short-tank Centaur, common for both DOD and NASA, could be developed within the available funds, within Department of Defense and NASA funds. We did not look at whether it would be split between NASA, or Air Force, or DOD. We just put the funds in a pool and said, could we develop a short-tank Centaur, common for both users, that would meet the requirements for both DOD and NASA?

The results of that study were such that the Department of Defense and the Air Force made a judgment that the requirements to modify the payloads for the Department of Defense to adapt to a new upper stage, now Centaur, since they had already been designed for the IUS, was sufficiently uncertain in terms of cost and risk of the schedule for launching DOD payloads. We could not do that in the timeframe dictated by the NASA schedule, which was 1985. We felt that the risk in cost and schedule were too high. And therefore, the decision was made that we would not proceed with the short-tank Centaur.

But as a result of that study, we clearly saw the projected need. There is no firm requirement that I can point to right now, not a firm requirement, but a projected need by about late 1987, we could see the requirements for additional capabilities on our satellites such as that required to improve its survivability or improve the coverage or improve the surveillance capabilities of our satellites, such that the weights could grow beyond the IUS capabilities. And therefore, we felt that it was a prudent decision to proceed now with reprograming existing Air Force funds in fiscal year 1982 to begin that joint program.

And that's what we've decided to do.

Senator Schmitt. Do you understand the difficulty that we have with those explanations? This committee.

Mr. Aldridge. Yes, sir.

Senator Schmitt. I mean, it may make all the logical sense in the world to the Department of the Air Force, but they make very little sense to those of us who are both on this committee and on the Appropriations Committee. We're looking at a significant increase in funding for a separately developed vehicle for the Air Force, at a time when we thought that everybody was ready to move forward with a very similar vehicle for use by NASA, and subsequently, by the Department of Defense.

Do you understand why we've got a problem with this one?

Mr. Aldridge. The problem, I think, that is being perceived is that we could save some money early in time by proceeding with such a joint program.

Senator Schmitt. Yes; we can save some money and we can have a capability for NASA at a time when it would be very useful to have it.

Mr. Aldridge. But the problem is that the funds that are being projected to be saved may not be, in fact, the case. Those funds do not include the DOD add ons that would be required for transitioning between the IUS and the Centaur. As I mentioned in my statement, we would have to go back and buy additional Transtage vehicles and an additional backup booster to handle those payloads that would be at risk result of the cancellation of the IUS. It does not include the cost, the potential cost, of payload modifications necessary to DOD payloads. The analytical model has not been developed for the Centaur to assess whether or not the vibration and acoustic effects on our payloads could be handled. We did not know that.

And, if we get into a situation where those effects would force a redesign of the interface between the Centaur and the DOD payloads, or some other part of the payload, those costs could be astronomical. And then it could have the additional effect of delaying the launch for those critical DOD payloads, and that was unacceptable. We did not have that information and could not find out that information before we would have to commit to a Centaur development.

That was an unacceptable position for the Department of Defense to be in. And those costs are unknown at this particular time.

Senator SCHMITT. Also unknown are the costs of not having the higher energy upper stage.

Mr. ALDRIDGE. No, sir; the IUS, as it is currently designed, will meet all DOD payloads out through 1987.

Senator SCHMITT. Are you saying that no spacecraft modifications would be required to be on that?

Mr. ALDRIDGE. Sir, we think that there are additional pressures being raised on the Department of Defense to increase the weight of our payloads beyond that timeframe, as I mentioned, for improvement of survivability, for additional payload packages that would go onboard those satellites, and for additional communications and cross links that would remove our dependency on overseas grounds stations.

All of those are pressures. They are not firm requirements at this point. But I can clearly see that if we have such a capability, an increased capability, over IUS in late 1987, we could certainly utilize that capability. And it's for that reason that we decided to proceed on with some type of higher energy upper stage for that timeframe. Up until that timeframe, IUS will meet all of our requirements.

Senator SCHMITT. Your memorandum also states that in order to keep costs of the new development program manageable, the higher energy upper stage program should be based on existing technology and reduced avionics.

Would you care to explain how that relates?

Mr. ALDRIDGE. Yes, sir; I'm trying to keep the cost from being $1 billion.

Senator SCHMITT. Doesn't that mean that you're going to have to go with the Centaur technology?

Mr. ALDRIDGE. If the Centaur is the right answer, that's fine.

Senator SCHMITT. Well, what other existing technology and reduced avionics system is there?

Mr. ALDRIDGE. Transtage. We can use a modification of the IUS, or some other new stage might be appropriate. In a competitive environment, all those new ideas might be——

Senator SCHMITT. With the problems the IUSs have, is that the way you would——

Mr. **Aldridge**. The problems with the IUS has been one of cost, not one of performance. The performance specs are meeting all——

Senator **Schmitt**. Well, there have been some design problems with the IUS, have there not?

Mr. **Aldridge**. Those are translated into the cost. The cost and schedule have been a problem.

Senator **Schmitt**. That's another reason why I wonder whether you really can count on a 1987 IOC.

Mr. **Aldridge**. Well, if we don't use IUS——

Senator **Schmitt**. Even the late 1980's, IUS, particularly, if you're only going to put $4 million into it this year.

Mr. **Aldridge**. That's the beginning part of it, sir. It's a joint program between ourselves and NASA.

Senator **Schmitt**. I wish that we could still do what we used to be able to do and get these systems online and produced in a reasonably short period of time. Leadtime is one of the most serious problems we all face.

Mr. **Aldridge**. The Centaur program that was being proposed, the short-tank Centaur, was going to be from go-ahead to delivery, which was going to be 36 months. That was a fairly short, very aggressive schedule.

Senator **Schmitt**. Would you expect NASA to contribute to the development of this higher energy upper stage?

Mr. **Aldridge**. Yes, sir.

Senator **Schmitt**. Why would you expect them to contribute to yours when you won't contribute to theirs?

Mr. **Aldridge**. We are starting off with a joint study to look at joint requirements. And I believe that we are putting up $4 million in fiscal year 1982 and I believe NASA will put up some small percentage to make sure that we can make it compatible with the Shuttle design.

How it is then developed, under whose responsibility, is a subject to be determined as a result of this particular effort. If it is, in fact, some modification of a Centaur, then it maybe is more appropriate for NASA to pick up the responsibility. If it is another version of a different stage, it may be more appropriate for the Air Force to pick up the responsibility.

That is something that has yet to be decided.

Senator **Schmitt**. Let me tell you, there's still a strong smell in this whole thing that with respect to this vehicle, with respect to the fifth orbiter and subsequent orbiters, and with respect to the filament wound case, you guys want a free ride. That's been around for a long time.

Mr. **Aldridge**. You mentioned earlier——

Senator **Schmitt**. And I know about the agreements. I know that you're building Vandenberg. I know that you're doing a bunch of other things, CSOC, and the like, presumably. But it still looks like the things you are actually going to use, you want somebody else to hand to you. And if they don't arrive on the scene, you're going to say, it's not our fault that we have a $1.4 billion CSOC sitting there without a Shuttle to fly, to use it, that we have a launch facility on the west coast without a Shuttle to launch from it. Sorry, we did our part.

Mr. **ALDRIDGE**. I don't know how to answer your question there, sir. I'm not sure what the question was.

We are proceeding with an agreement in which we did, in fact, proceed with the Vandenberg. There have been some very large cost increases in Vandenberg. We did not go back and try to say, well, NASA should pick up those. There have been some significant cost increases in IUS. We didn't go back and say, hey, let's reopen the agreement because those costs should be shared by NASA, because it is a joint program.

We did not go back and ask for more money for payload integration within the Shuttle because those had to be redefined as we went through the development program. We felt that we met up to our share of that original agreement, and we feel that NASA should meet their share of the original agreement. And that's what I think they're doing.

Senator **SCHMITT**. Yeah, but what you're also saying is if NASA can't do it, then too bad. OK? If the Congress, or the administration, or Dave Stockman or OMB won't let NASA get the funds necessary to live up to their part of the agreement, then what you're really saying is, tough luck. We'll go do it some other way.

I've got to go vote again. I'm sorry. This one you can't blame on me.

[Recess.]

Senator **SCHMITT**. We'll come to order.

Mr. Secretary, I am most apologetic. This zoo that we have going on over on the floor is going to continue. I'm going to have to ask questions for the record. We do have a visitor from France here with us. We must hear from him. I just don't know how much time we're going to have.

So if we could ask the remainder of our questions for the record, I want to thank you very, very much for being here today and for your candid responses. I'm sure that the dialog will continue and I look forward to it.

Thank you.

Mr. **ALDRIDGE**. Thank you.

[The statement follows:]

STATEMENT OF EDWARD C. ALDRIDGE JR., UNDER SECRETARY OF THE AIR FORCE

Mr. Chairman and Members of the Committee—I am very pleased to appear before you today to discuss the United States Air Force participation in the development and operation of the Space Transportation System (STS). I appreciate the strong support this Committee has provided to the Space Transportation System in the past and look forward to a future of continued cooperation toward achieving an operational Space Transportation System which is fully capable of supporting our national goals.

My responsibilities include both the Air Force development and operations activities within the Space Transportation System and the development and operation of a significant proportion of the Department of Defense space satellite programs. Today I plan to discuss our Air Force responsibilities and views on the Space Transportation System, the transition of our payloads to the Space Shuttle, provide you with an update on Air Force progress within the STS development program, and discuss related organizational and management issues regarding the use of space systems to meet our national defense objectives.

As you know, NASA has the major responsibility for development of the Space Transportation System. This includes, of course, procurement of the Space Shuttle Orbiters and associated flight hardware; the development and operation of a launch and landing site at the Kennedy Space Center; and mission planning and flight control facilities at the Johnson Space Center. The Air Force responsibilities include the development and operation of the Shuttle launch site at Vandenberg Air Force Base for polar orbiting missions; development and procurement of the Inertial Upper Stage for use on both civil and defense space missions; and the development of a number of Shuttle related operational capabilities that are necessary to fully and effectively use the Space Transportation System.

We have been working with NASA to evaluate Shuttle performance against the needs of our own missions. We have been very pleased by the highly successful first and second flights of the Columbia, and we have every reason to believe that the Shuttle will support our defense payload requirements. We do have several areas of concern which we are following very closely; in particular our own assessment indicates that Shuttle performance is about 3,000 pounds below the nominal values, and that the reentry aerodynamics still have some uncertainties which could affect the center of gravity limits and thus—ultimately—the maximum payload capability of the Orbiter. These concerns, while important, are relatively small on the overall scale and we are confident that they will be adequately resolved in time to meet defense mission requirements.

From our perspective, Orbiter production schedules are adequate to our needs. We expect the available Orbiters to meet our mission requirements, beginning in 1983 at the Kennedy Space Center. NASA is planning to operate Orbiter 103 at the Kennedy Space Center after its delivery in September 1983 and provide it to us in February 1985 for activation of the Vandenberg launch site. Delivery of Orbiter 104 in December 1984 will provide the second full performance Orbiter; this will greatly increase our confidence that the Shuttle can satisfy our most demanding missions.

I also believe it is important to maintain a continuing Orbiter production capability, both to support what I expect to be increasing flight demands and to provide some margin for attrition to the Orbiter fleet. While a four Orbiter fleet will satisfy our currently our currently projected defense launch requirements, it also appears to significantly constrain the growth of the civil traffic which will be the real key to economical STS operations. Further, the four Orbiter fleet contains only two full performance Orbiter vehicles—OV-103 and OV-104. Damage to either of these Orbiters could place the nation in the highly undesirable position of having only one fully capable Orbiter vehicle. There are a sufficient number of missions which demand full Shuttle performance that such a circumstance would be intolerable for the nation. Consequently, I believe it is wise to continue with the procurement of the fifth Space Shuttle Orbiter, and I applaud the recent NASA initiatives to obtain additional economies in that procurement by structuring it as a "block buy" with Orbiter 104.

We are now nearing the end of the nominal developmental phase of the Shuttle program and about to embark on its operational use. This is the objective for which the Space Shuttle was designed, and significant challenges still lie ahead of us for the Shuttle to be successfully employed in this operational role. As we have so often learned in defense systems, many new problems will likely arise during the transition to operational activities with the Shuttle. Solving those operational problems will not be as glamorous; but, it will become the demonstration of our real commitment to an expanding use of space systems for the defense of this country and for the benefit of mankind. I am convinced that we can succeed in this endeavor, but it will be more important than ever to have full support of the Congress to do so.

The Air Force has made a strong commitment to use the Space Transportation System in support of our space operations. We have planned a systematic program in which our activities are keyed both to the NASA Shuttle milestones and to the needs of our operational defense space programs. We have committed all of our operational space programs to transition to the Space Shuttle. Indeed, our mission will begin during the Shuttle Operational Flight Test period. We will place a DOD experiment on the fourth OFT mission that will provide information applicable to future defense missions. It will also be a pathfinder so that NASA and the Air Force will have an early opportunity to evaluate mission and security procedures and interfaces for the Shuttle operational era. We will begin the transition of our operational space programs to the Shuttle in late 1983 at the Kennedy Space Center. Our polar launched defense payloads will be in their transition in late 1985 immediately after the Vandenberg launch site becomes operational. Most major defense payloads will have completed their transition to use of the Space Shuttle as their primary launch vehicle by 1987. A number of our most critical missions are being optimized for Space Shuttle flights and will be no longer compatible with our expendable launch vehicles; thus, the Shuttle has become an essential element of our national defense posture.

Because of the critical nature of our defense space missions during the Shuttle transition period, we have maintained a backup for selected critical programs through the procurement of additional Titan launch vehicles. Our backup philosophy was based on several principles; first, to cover the uncertainties associated with the Shuttle development and the Kennedy launch site development on the east coast; second, to cover the uncertainies associated with launch site development at Vandenberg; and finally, to maintain a continuing Titan production capability at least until the Shuttle achieves its initial operational capability at the Kennedy Space Center. We have a sufficient number of Titan vehicles to meet our basic backup objectives at both Kennedy and Vandenberg. The Air Force fiscal year 1983 budget submission contains funding for "advance buy" materials for two additional Titan boosters in order to maintain production capability.

Now I will discuss the status of our Air Force development activities in the Space Transportation System program.

As you know, we will acquire and operate the STS launch and landing facilities at Vandenberg Air Force Base. During 1981 the Air Force conducted an executive level program review of our Space Shuttle development activities—the Vandenberg Shuttle launch site IOC date was a major focus of that review. A combination of manpower and technical issues forced us to delay in the Vandenberg IOC from August 1984 to October 1985. We were faced with a critical shortage of contractor engineering manpower at Vandenberg and this shortage exacerbated all the problems. We have also experienced a number of engineering changes as both we and NASA better understand the Shuttle system—these impacted the design of equipment, software, and facilities. We had, over a period of time, increased the concurrency between Vandenberg and Kennedy so that the construction schedules were about one year closer together than originally planned; this further compressed our engineering time. We are also faced with technical challenges which were unique to Vandenberg; these included erecting and mating the Orbiter on the launch pad and controlling ice buildup on the external tank. Consequently, we selected October 1985 as a realistic IOC target which balances the competing requirements. This schedule accommodates realistic projections for the buildup of engineering manpower. It relieves excessive schedule risk. It allows orderly resolution of the technical issues.

I would like to briefly address one of the most significant of the Vandenberg technical problems—one which was a factor in our IOC decision. We had been planning to erect the Shuttle Orbiter and mate it to the previously assembled External Tank and Solid Rocket Boosters. Using a strongback mechanism which would lift the Orbiter, rotate it to the vertical and position it for final mating. This activity was planned to take place in the open environment on the Vandenberg launch pad as opposed to the more benign environment in the Vehicle Assembly Building at the Kennedy Space Center. Our baseline design was geared to what both we and NASA believed were reasonable tolerances—approximately ⅛" to ¼"—in the Orbiter to external tank fittings (this tolerance is necessary to accommodate the random motions generated by the process of joining the two masses). However, once NASA had successfully stacked the actual flight hardware in preparation for the first Shuttle launch and completed the analysis of that data, they reduced the mating tolerance to about 1/32" to protect the integrity of the mating fittings and to insure a safe separation of the Orbiter from External Tank in flight. This tolerance requirement significantly exceeds the capability of the Vandenberg "strongback" system. For example, if the wind changes by as little as two knots—say from 10 to 8 or 10 to 12—the deflections in the structure holding the Orbiter compared to the relatively stable External Tank would exceed the allowable 1/32" tolerance. Consequently, the Air Force Space Division and NASA conducted studies with three independent contractors which resulted in all three recommending that an environmental facility be built to protect the Orbiter during the mating operation. That shelter is included in our fiscal year 1983 military construction funding request. Although this decision was made primarily to solve the mating problem at Vandenberg, I also believe that it will have long term operational benefits and, consequently, is likely to provide some operational economies as well by providing weather protection for the launch crew and the Space Shuttle Vehicle prior to launch.

The Vandenberg development has been restructured to achieve the October 1985 IOC. The engineering design, equipment procurement, and military construction activities are progressing at a pace which supports achieving that objective. Let me give you just a few brief highlights of our status: construction of the Orbiter Maintenance and Checkout Facility is now more than 75 percent complete; our Solid Rocket Booster Processing facility construction is over 50 percent complete; the External Tank Processing Facility construction is more than 80 percent complete. The runway extension is now under construction; and a number of other supporting facilities are either complete or under construction.

The major construction work at Vandenberg is on the launch complex and we are making significant progress there as well. We have completed construction of the Launch Control Center and have installed most of the equipment in that facility; we are testing that equipment now. Our contract for the construction of the Payload Preparation Room, the exhaust ducts and the launch mount, and the associated mass concrete and service areas is more than 55 percent complete. Our contract for building the Payload Changeout Room and modifying the Mobile Service Tower is now more than 30 percent complete, and erection of the Payload Changeout Room has begun. Unfortunately, the cumulative effect of the technical uncertainties and problems with estimating the cost of the resulting engineering changes has resulted in the need for an additional reprogramming action in fiscal year 1982. We have recently submitted that request to the cognizant congressional committees. That action is urgent and will require immediate approval for us to maintain our schedule leading to the October 1985 IOC.

Our current plans for activation of Vandenberg call for delivery of Orbiter 103 in February 1985 for a period of some 8 months to prepare the Orbiter Maintenance and Checkout Facility and the launch pad leading to launch of a DOD mission in October 1985. We are working with NASA on a study which considers the "off-load" of certain selected tasks—including Orbiter processing—to the Kennedy Space Center for the initial operational period. This could allow us to gain additioanl time at Vandenberg to assess Shuttle progress at Kennedy and incorporate that learning into our Vandenberg baseline while still supporting our launch call-up requirement in October 1985.

This first Vandenberg launch will require full specification Shuttle performance—as called out in our Performance Reference Mission 4 requirements. Specifically, the Shuttle must be capable of delivering 32,000 pounds to a 98° inclined, 150 nautical mile circular orbit and, then, recover another satellite weighing 25,000 pounds and return it to Vandenberg. The Shuttle with its current performance estimate cannot achieve this long standing defense requirement. Consequently NASA has, with our agreement, decided to proceed with implementation of the filament-wound Solid Rocket Booster cases which will bring the Shuttle performance to the required level. We fully support that action as a mandatory step to meeting our mission needs.

I will now turn to the discussion of our Inertial Upper Stage Program. The IUS development has been a rather turbulent one, with significant schedule extensions and major cost growth. It appears that much of the IUS difficulty stems directly from what I can only call "over optimism" in our initial cost and schedule projections, combined with the additional uncertainties imposed by the ongoing parallel development of the Space Shuttle vehicle. The program, however, has been and continues to be technically sound, and our performance projections indicate that, as expected, the IUS can meet all of our near-term requirements for Earth-orbiting missions. Specifically, we currently project that the IUS can place 5,090 pounds into a geosynchronous orbit (90 pounds more than its specification) and that it has the energy capability to place approximately 11,800 pounds in a twelve-hour elliptical orbit—assuming the availability of a full performance Space Shuttle. The injection accuracy and launch reliability projections also meet or exceed the approved program requirments.

We have had significant progress on the IUS development program. The Qualification Test Vehicle completed its system level qualification testing in December. Component qualification is now complete. The pathfinder test vehicle for the Titan IUS configuration has finished its testing at Cape Canaveral Air Force Station and the pathfinder for the Shuttle configuration arrived there in December. The operational flight software for the first Titan IUS flight has completed both verification and validation testing and is under Air Force review. The Shuttle IUS software verification is 50 percent complete and on schedule and will be available in September 1982—well before the first planned flight date. We have completed the development testing on the solid rocket motors with 18 successful firings and have begun the qualification test program which will be complete in mid-1982. We have every reason to believe that the IUS can perform its intended missions, albeit at a higher cost than we had originally anticipated.

The Air Force executive level program assessment review—which I mentioned earlier—confirmed the sound technical status of the IUS program. However, it found that IUS availability—while still meeting mission requirements—would be delayed until mid-1982 for both the Titan and Space Shuttle configurations. It also found that IUS vehicles would experience additional cost growth—primarily in vehicle production—as a result of earlier development problems and the NASA termination of the planetary mission IUS variants. Consequently, we are preparing to submit a reprogramming request to cover these increased costs in the IUS production. Following Congressional approval of our reprogramming request we will proceed with a production buy of 5 IUS vehicles, 3 of which are for Defense use and 2 which are for NASA missions.

I would like to briefly discuss our requirements for a higher energy upper stage for use in the Space Shuttle. I believe that the nation needs an additional capability to complement the ISU capabilities and provide us an available option for higher performance in the late 1980's. I conducted a thorough assessment of the programmatic options which could have enabled that to happen. However, all the affordable available options resulted in an unacceptable level of risk for our Defense launch capability. Specifically, we investigated a Centaur configuration and found that it does not envelop the defense payload requirements. Further, the time necessary to define those requirements in contractual terms would have significantly delayed the beginning of the Centaur development effort. That delay would not only have impacted the availability of the Centaur to support NASA's galileo mission to Jupiter, but would have resulted in the strong possibility that we would have had no launch vehicles available to fly critical Defense missions in the mid-1980's when our current supply of IUS vehicles would have been exhausted. Finally, we were unable to identify firm Defense requirements close enough in the future to justify proceeding on a sole-source basis for a Centaur for Defense needs alone. Consequently, we have chosen to pursue joint DOD/NASA early definition studies leading to the development of a higher energy stage for the 1987 to 1988 time frame. We will include funding with our IUS reprogramming request to perform the initial studies in FY 82 leading to that capability. Our current plan is the initial studies would be followed by a competitive procurement leading to an early start of full scale development.

Now I'll finish discussing our Shuttle development efforts. As you know, a significant amount of related efforts is required in order to actually employ the Space Shuttle operationally. I will briefly mention some of our operational capability development activities. We have now begun construction on a Shuttle Payload Integration Facility to use in the physical integration of Defense payloads prior to placing them in the Orbiter. The SPIF is located at the Cape Canaveral Air Force Station and is on a schedule which will support our first operational missions in 1983.

We must operate Defense missions under secure conditions, and we are funding modifications to the NASA facilities which allow us to do so while simultaneously retaining the essentially open nature of the unclassified NASA operations. The "controlled mode" modifications are well along at the Johnson Space Center and will be coming on line incrementally to support our defense mission requirements. We will also be making modifications to the NASA facilities at Kennedy Space Center and the Goddard Space Flight Center in order to protect DOD classified data present during our Shuttle missions. We now have an additional assessment under way. We will keep you apprised of our progress in this area.

The Consolidated Space Operations Center will be an important element in our space operations as we evolve to a more robust capability. Design of the Satellite and Shuttle control systems is underway and construction will start in 1983. Satellite operations will commence in late 1986 with CSOC functioning as an intergral part of our worldwide satellite control network. Shuttle missions will be conducted from the CSOC starting in late 1987. CSOC will have a unique role in military space operations as we extend the military applications of the Shuttle.

This summarizes the status of our Air Force Space Shuttle development efforts. Now I would like to discuss our plans to exploit the capabilities available with the Space Shuttle.

The Space Shuttle is extremely important to the DOD and we have made a major commitment to its use in support of our missions. I believe the Shuttle is key to an expanded Defense space program. We have seen an ever-increasing dependence upon our defense space systems in order to maintain our national security, and we are making the necessary changes to exploit those capabilities. However, the key to fully exploiting the space medium for our national defense is to develop an adequate base of skilled and dedicated people. These unique skills are currently available only in relatively small numbers. We are committed to develop a significantly larger base of management and technical talent capable of conducting an expanded defense space program. We have already taken the first steps by establishing an organizational structure which can evolve as necessary without undue encumbrances. We have established the Air Force Space Division separate from our ballistic missile activities; and within the Space Division we have designated a Deputy Chief of Staff for Space Operations.

We have also established, at the Johnson Space Center, the Air Force Manned Space Flight Support Group which will develop the experience base necessary to conduct DOD missions using the Shuttle and become the cadre for our eventual transition to the Consolidated Space Operations Center which we are planning to build near Colorado Springs in the late 1980's. We also provide many of the skilled pilots who become the NASA astronauts and we are working a program with NASA to train payload specialists for use on defense Shuttle missions. We have also assigned one of our best program managers, Major General Jim Abrahamson, to NASA in order to help bring the Shuttle into operation. All of these activities will help us develop the experience base necessary for an expanded defense space program. We are continuing to assess the organizational and management actions necessary to exploit fully the advantages of space systems for our national defense.

I also believe it is now particularly important that we take every opportunity to demonstrate the Space Shuttle's unique capabilities so that all of our program managers can, with confidence, plan and execute their programs based on having these new and unique capabilities available. For example, I believe it is very important for NASA to conduct the retrieval and repair of the Solar Maximum Spacecraft and to launch and demonstrate the viability of on-orbit maintenance with the Space Telescope. We also need to see the Remote Manipulator System in active use in order to increase confidence in our planned missions which use the RMS and to encourage the future programs which can be based on its demonstrated capabilities. We need to take every other reasonable opportunity to demonstrate the Shuttle capabilities and make them part of our space operations particularly where we can make effective use of "man-in-the-loop" to execute complex and demanding space missions. These early steps will have a payback many times their cost by encouraging earlier use of Shuttle's unique capabilities in our space programs. I encourage this Committee to support these kinds of pioneering efforts.

Mr. Chairman, this completes my formal statement. It has been a pleasure for me to have this opportunity to discuss the Air Force role in the Space Transportation System. Thank you very much.

[The following information was subsequently received for the record:]

QUESTIONS OF SENATOR SCHMITT AND THE ANSWERS THERETO

Question. What are the current Air Force plans for monitoring the production of Titan launch vehicles?

Answer. One of the key elements of our Space Shuttle backup plan is the maintenance of critical Titan III production capability until at least the Initial Operational Capability of the Space Shuttle at the Kennedy Space Center (now November 1982). Tital III vehicles now being built or authorized for production will maintain the critical Titan III production capability until September 1983.

The fiscal year 1983 President's Budget, as submitted to Congress, contains funds to procure advance buy materials for two additional Titan III(34)D backup boosters. Procurement of these advance buy materials in fiscal year 1983 will enable the production capability to be sustained without interruption; however additional funding will be needed in fiscal year 1984 if the production capability maintenance is actually to be extended to September 1984.

The Air Force is currently evaluating the need to maintain Titan III production capability beyond September 1983, and the results of this evaluation will be included in our inputs to the OSTP Space Policy Study.

Question. Please identify the Air Force organization responsible for coordinating with NASA on the requirements for a space station and for the use of manned space activity.

Answer. Coordination with NASA on space station requirements will be handled within Headquarters USAF under the guidance of the Office of the Secretary of the Air Force. Brigadier General John Storrie in the Office of the Deputy Chief of Staff for Operations Plans and Readiness and Brigadier General Bernard Randolph in the Office of the Deputy Chief of Staff for Research, Development, and Acquisition share this responsibility, with General Storrie in the "lead" role at this early stage of requirements definition.

Question. Does the Air Force currently see a need for a mission similar to the Solar Maximum Mission (SMM) repair mission currently planned by NASA, that is, does a Satellite exist in low earth orbit which uses similar hardware whose repair or return would effect significant savings for the Air Force? If SMM were to be returned would the Air Force have a use for the refurbished hardware?

Answer. Yes; in addition to placing a valuable satellite back in operation, the Solar Maximum Mission will demonstrate Shuttle capabilities which have value to Defense and civil missions. These capabilities include:

a. Rendezvous with the SMM satellite.

b. Extra-vehicular activity (EVA) which places significant demands on both the man and his maneuvering unit to grasp and stabilize a tumbling satellite.

c. Use of the remote manipulator system (RMS) to grapple the satellite.

d. Use of RMS to place the SMM satellite in its cradle.

e. EVA to remove and replace the failed components, i.e., on-orbit repair.

f. Checkout of the repaired satellite.

g. Return the SMM satellite to its operational orbit.

We have Defense missions which require retrieval of the orbiting satellite for refurbishment and reflight. Many of the specific tasks to be performed on the SMM are directly applicable to our missions—as well as to important civil missions like Space Telescope.

Perhaps more important, the SMM repair will give us time to solve any problems which develop before we must recover a critical Defense spacecraft. We may learn enough from the SMM repair to avoid problems (perhaps including loss of a satellite) on future Defense and civil missions. A successful demonstration will also increase the confidence of our satellite program managers and thus is likely to hasten the exploitation of Shuttle-unique capabilities.

The SMM hardware, if returned and refurbished, would not have any immediate direct application to Defense missions. However, if it is not used for a near-term civil mission, it would provide a pool of valuable government assets which would undoubtedly find productive use in future Defense or NASA missions.

Senator **Schmitt**. Our next witness, a very much appreciated witness, is Monsieur Frederic d'Allest. Welcome, sir. Mr. d'Allest is the president, director general and chief executive officer of Arianespace.

We appreciate you being here. Please proceed with your prepared statement, and if you could, I see it's reasonably short, but if you could, stay within 10 minutes and then we will have some questions for you.

STATEMENT OF FREDERIC D'ALLEST, PRESIDENT, DIRECTOR GENERAL AND CHIEF EXECUTIVE OFFICER, ARIANESPACE, EVRY, FRANCE

Mr. **d'Allest**. Mr. Chairman, I am very honored to have been invited to testify on our Ariane activities in front of such a distinguished assembly.

Upon the invitation of Senator Schmitt, I have chosen to offer you a short survey of the Ariane program status, on the background and the content of Arianespace, our views on the launch services market and on the new and growing competition between U.S. launch vehicles and the European Ariane launch vehicle.

You are certainly aware that Ariane 1 is a classical three-stage launch vehicle, specifically designed to launch application satellites in geo-stationary transfer orbit. The very modern French Centre Spatial Guyanais in French Guiana has also been selected to allow maximum use of Earth rotation velocity, near-equator plan, in order to reach this specific orbit as economically as possible.

This, the major program of the European Space Agency, funded by 10 Western European countries, was decided in July 1973 with an operational target of 1981. Today, the flight certification of Ariane has been officially achieved, 1 year following the target date, but within the financial contingency margin decided 9 years ago. The performance largely surpassed the objectives.

In order to enhance the Ariane capability, an Ariane family concept was studied as early as 1977 in order to meet the increasing size and weight of the satellites, planned in the eighties, and to meet the U.S. launch vehicles— particularly the STS—competition.

The philosophy is to minimize changes in the design of the Ariane 1 vehicle, in order to keep the same production line, and to generalize a dual launch policy to facilitate cost-sharing between two customers.

We are convinced that, in this way, we are marketing an excellent line of products of meeting, with a very good flexibility, the needs of the customers.

The accuracy of the injection into orbit, the very quiet environment of the payloads, the easy integration and making of the satellites and the launch vehicles, the straightforward procedure of injection into GTO, are providing the customers with a first-class launch service.

The availability of a good product for launching automatic satellites, the dramatic expansion of the application satellites market has led CNES, the French National Space Agency, to propose to the European Space Agency and to European industry the establishment of an industrial and commercial corporation. Arianespace was incorporated on March 26, 1980, with a joint stock of some $20 million. Its 50 shareholders, dispersed among CNES, European industry and banks, represent a powerful association.

Following a decision by the participating States of the Ariane program and a convention between ESA and Arianespace, the responsibility for the production, marketing and launching of operational Ariane launch vehicles and their upgraded versions is entrusted to this company. Within this legal framework, Arianespace is fully responsible, at its own risk, to produce and sell an all-inclusive launch service to its customers, including ESA, CNES and other European clients.

There is no transfer of money between Arianespace and ESA and the other European organizations other than the payments due to Arianespace within the framework of the launch services contracts negotiated and established for each payload, and a fee paid by Arianespace to ESA, to share the expenditures of the CSG range for each launch.

When establishing Arianespace, we succeeded in convincing ESA and its member States that the STS pricing policy during the first 3 years of its operations involved a huge subsidy, thus creating an unfair competition. In response, it was agreed that for the European payloads launched before mid-1986, the standard price negotiated with ESA and specified in the ESA/Arianespace Convention would include a 25-percent extra charge to support the company.

We consider, and I hope you will consider, that these practices are not very sound, as they charge the research and development programs on both sides of the Atlantic, instead of charging the users who reportedly look to gain great financial profit from their commercial applications.

We permit ourselves to underline the fact that the orbiters 'production costs should also be fully charged to the customers, with the related cost of money.

As long as the STS production and operation costs do not reflect realistically the STS pricing policy, we shall claim some support through the European payloads launch prices, to ESA and its member States.

Before going to my conclusion, I shall commence some slides.

[Slides shown.]

You have in this slide a view of one of the first Ariane launched from Kourou. Kourou is in French Guiana, just north of Brazil, and it's launched from the same launchpad from the equatorial plain to the polar orbit and the Sun-synchronous orbit.

You have here a view of the launchpad, with the launch tower, umbilical masts, and the water tank at the left.

A view of the block house.

And one of the control center.

On this shot is shown the so-called Ariane family. On the left, Ariane 1. She is capable of 1,800 kilos in transport orbit. The Ariane 2 and 3 version are under development and will enter into operation in the middle of 1983. Ariane 3 has been specifically designed to be able to launch in the same launch to STS. And Ariane 2 is the same thing as the Ariane 3, without a strap-on booster that the mission does not require.

We have now, and it has been formally decided by the European Space Agency, to bring on development of the Ariane 4 family.

The Ariane 4 family has been designed to be a very flexible family of vehicles. The core vehicle is the same, to have a cost-effective production line, and the missions' requirements are filled with various combinations of liquid and/or solid strap-on boosters.

On the left Ariane 40 is equivalent to the Ariane 2 for mainly Sun-synchronous orbit. The 42P is with two solid boosters. It is equivalent to the Ariane 3 and will replace Ariane 2 and 3. And then there are progressive degrees up to the 44L, with which we launch 4,200 kilos in transfer orbit. That means twice the performance of Ariane 2. This will enter operations in 1986, after a demonstration flight, which is planned in October 1985.

This is to illustrate how the Ariane family compares with various launches. In the clear blue, the Ariane 1, 3, and 4, is in its most powerful version, and you see the Ariane 1 is very near the Atlas-Centaur. Ariane 3 is very near the Soviet Soyuz launch vehicle. And Ariane 4 is very near the Titan 3 launch vehicle.

Arianespace is a very classical and ordinary corporation—50 shareholders in the aerospace industry in Europe, 13 important European banks, and CNES, the French National Space Agency.

As I said, Arianespace is in charge, not only of the marketing, but is, in fact, in charge of the production in Arianespace. It is in charge of prefinancing the production and then financing, if necessary, the contract launch services, in doing the marketing, and is also conducting the launch operation.

You can see that the list of shareholders is extensive. Eleven countries are involved. And there is a large association of banks because financing the production of such a project demands, as you know, a big amount of money.

Our last market study shows that in the 1985 timeframe, the potential market is for some 178 spacecraft over this period of 6 years, excluding Eastern countries.

And our ambition in this competition is to take a share of some 30 percent of this market. That means that we plan in the second half of the 1980's to launch some 50 to 60 spacecraft.

We have here a list of the firm orders and reservations, which show that we are planning a launch rate of five launches per year in 1983 and 1984, and after putting into operation a second launch pad, we plan to go from 7 to 10 launches per year from 1985 onward.

We are now completely booked for 1984 and we are making arrangements for 1985. For 1985, we have already six launches firmly ordered, and we are obligated for two other launches.

To conclude this briefing, I would like to inform you of our views on the existing market and which share we have the ambition to grasp.

Our last market survey has identified, on a realistic basis, for the 7-year period of 1985 to 1991, Ariane's potential market of some 178 satellites. These figures cover the Western world and exclude payloads incompatible with the Ariane family. We aspire to capture some 30 percent of this market.

As of today, 32 satellites are firmly booked—contracts signed—on Ariane for the benefit of 15 customers around the world. In addition, Arianespace has signed launch reservation agreements with 7 customers for 9 payloads.

We have just ordered from our suppliers an increase in production rate from one vehicle every 2½ months to one vehicle every 1½ months.

With a second pad under construction, our launch rate should increase from approximately 5 to 6 launches per year until 1984, to some 7 to 10 launches per year in the second part of the decade, when the new facility will begin service.

We are convinced that the establishment of Arianespace company has created a healthy new situation in the launch services field. In our Western world, commercial applications in a worldwide launch service market of some $10 billion means competition. I hope it will be a fair and reasonable competition.

Now that a monopoly is over, and that a challenger has appeared on the scene, I am sure that you will consider, in the genuine American tradition, that this new situation will be profitable to the customers, the United States and European taxpayers, the space agencies, and the development of space activities.

Thank you, Mr. Chairman.

Senator SCHMITT. Thank you, sir. We appreciate that testimony very much. We appreciate your being with us today. We also appreciate this very fine ad that appeared in Aviation Week recently.

And I, for one, think that it's extremely important that the free world is now developing a diversity of space capabilities, some in competition, some in cooperation. I have no problem with that. I don't think anyone should, so long as we all work toward a fair, competitive environment, which I know is certainly what you would like to have. There will be arguments back and forth about who is being fair and who is being unfair, but that's the way it usually is among friends.

If the United States were to turn the Space Shuttle operations over to the private sector, how would you see this as affecting the competitive environment?

Mr. D'ALLEST. Well, I think, personally, that if this was happening, it would create the situation for us perhaps clearer—I don't say better, but clearer—insofar that Arianespace, the board of directors, the financiers, the bankers, must have a very clear account of what is charged to the production and to the operations because, as I said, we must survive with our income and our expenditure. It is a rule of the corporation. We must have a net cash flow to refurbish and renew several things, several transportation facilities system. And if it was the case in the space transportation, it would also make clearer the ways the pricing policy is balanced.

As I said, we are very visible, with a one-line product. We have to balance our company. And you know a situation of shared capital is always extremely difficult. It would be perhaps clearer from that standpoint. But there are many other aspects which are beyond my competence in this consideration.

Senator SCHMITT. I recognize your difficulty with some of the pricing policies followed in the space transportation system, but I think you must also recognize that the United States is attempting to develop a capability that not only serves the commercial and public sector, but also serves the defense sector of our Nation, as well as the free world. There is some overriding value to that. The difficulty is in setting what that value is, even to France. There is, at least in my opinion, some value.

What are the factors that you feel will allow Ariane to be fully competitive with the Shuttle and indefinitely competitive? The family that you're developing, the launch schedule, I presume, are all part of that, plus the cost.

Mr. D'ALLEST. Well, Mr. Chairman, first I would like to say that with Ariane, we have a much more modest objective than the Space Shuttle and I am full of admiration for the Space Shuttle program and its objectives and its capabilities.

Our target is, as you know, particularly into the geo-synchronous orbit and Sun-synchronous orbit to have our room and our position.

The basic reason why we are convinced that the Ariane kind of product is competitive, basically, and will stay competitive for at least 20 years, when improving it, is the fact that as it is an automatic system, as it is expandable, and as it has been designed specifically for geo-synchronous orbit, we can have a system much smaller than the Shuttle, which requires very big logistics and manpower and operation costs and so on. You can notice that Ariane's lift-off weight is 10 times smaller than the Shuttle lift-off weight, when in the orbit the ratio is some 2 or 2.5 only.

And basically, because the Shuttle has to carry dead weight—70 tons are coming back and forth which is not payload—this is one of the basic facts. Ariane is very conventional. We have voluntarily done some costs designs against our system because our target was not to develop advanced technology; it was to make use of our capability to have an operational system.

So I think that this is coming from the fact that the objectives are more modest, more narrow, and more specific. So, in the long-term, we consider, we are planning, together with CNES and ESA, a more advanced version of Ariane for the 1990s. But we do think, and it is one of the reasons why we are in space, that at least for 20 years, we shall be able to compete on a reasonable basis.

Senator SCHMITT. Well, certainly for those payloads where the objective is to put a certain weight within certain environmental constraints into orbit or into geo-synchronous orbit, the Ariane family should be very competitive with any vehicle in the world, I presume. But where one is dealing with other objectives besides just the lifting of payload, then, presumably, that market would be more readily filled by the space transportation system.

Mr. D'ALLEST. It is true. Presently, in Europe, we are discussing the possibility of space applications becoming important in low orbit. It would be for Ariane very difficult to compete with the Space Shuttle in low orbit. That is definitely clear. We are looking how to improve the situation.

Senator SCHMITT. You're familiar with Comsat as an organizational structure.

Mr. D'ALLEST. Yes.

Senator SCHMITT. Is Arianespace similar to Comsat as an organization?

Mr. D'ALLEST. I don't think so. Arianespace, as I said, is a very ordinary corporation. It has no specific links. We have, in fact, a normal board of directors. We have no specific agreements, except the fact that we are interested to use a launch vehicle design to produce it.

Senator SCHMITT. But don't you have a special relationship with the French Government?

Mr. D'ALLEST. No special relationship. CNES has been the promoter of the idea, but there are no special agreements whatsoever of transfer of funds between CNES and Arianespace. There are people who have been transferred from CNES to Arianespace to start the business, but there are no specific agreement of transfer of funds.

We asked CNES, for instance, to supply on a reimbursible basis quality monitoring or to do for us specific audit in case of review, but that's all.

Senator SCHMITT. What if a French competitor developed for Arianespace? I don't expect that to happen, of course, but is it conceivable that that might happen?

Mr. D'ALLEST. It is conceivable, yes. It could be decided, I don't know, a competition. There is nothing, at least legally, there is nothing preventing it. We have no monopoly in this respect.

Senator SCHMITT. You have a full go-ahead now for the development of Ariane 4 and Ariane 5 series.

Mr. D'ALLEST. Ariane 4. Ariane 5 is just into the paperwork.

Senator SCHMITT. When would you expect to have, as we say, a go/no-go decision on Ariane 5?

Mr. D'ALLEST. It will not be asked before 1984. There is at least a 2-year study. The target, at least from my personal standpoint, is that we should have an Ariane 5 with an advanced technology to replace Ariane 4 in 1993, 1994. At this time, we think we are well with Ariane 4.

Senator SCHMITT. Now according to the figuring that we made here in the committee, you have 32 satellites firmly booked and reservation agreements for 9 more payloads. The staff estimates that that's about 23 percent of the potential market in that timeframe. I don't know whether you would agree with that number or not, but it certainly puts you well on your way to achieving, I think, your initial goals for the launch capability.

Would you agree?

Mr. D'ALLEST. Yes. We think that when we claim for 30 percent, we think that it is realistic.

Senator SCHMITT. So your principal effort now will be to continue to market the capabilities of your operational vehicle while you develop new capabilities with the new vehicles that you have described to the committee.

Mr. D'ALLEST. That's true. But, Mr. Chairman, I must also say that one of our also major concerns is to continue to prove that we are a reliable vehicle. We have not the background of NASA and the experience, and we are putting a big emphasis on quality and reliability into operations, to be sure that the present results will be backed by the coming operations.

So this is also a big effort into this direction.

Senator SCHMITT. Do you see that the European space program overall, both those aspects that are competitive and those that are cooperative, is stable now and will grow, or do you see a reluctance on the part of governments within the European community to continue to support this kind of work?

Mr. D'ALLEST. I think that the achievement of Ariane and of this new small industry has been very well accepted and is very strongly supported in Europe. But it is also very clear that this does not exclude at all a cooperative program and particularly with the United States. This will remain certainly one of the lines of reason in the French agency and all the other agencies, to have a balanced program with cooperation and competition.

Senator SCHMITT. Has there been any discussion to expanding this generation of vehicles or a new generation of launch vehicles to include a manned space effort by the European community?

Mr. D'ALLEST. There are studies presently going on in CNES for a manned capability. There are today different schools of people saying we should do it or we should not do it. There are many questions.

I do think, personally, that we have the technology to do it with, obviously, more modest launch vehicle than the Shuttle. No doubt about this.

Senator SCHMITT. But no more modest than Titan.

Mr. D'ALLEST. We are studying today in CNES the capability of launching with an Ariane 5 version a manned and reusable winged vehicle. Studies show that there is no technology gap or basic difficulty to do it, and we might do it within 10 years if we would decide to go with that. Today, there are planning studies about doing some wind tunnel tests, some paperwork. But the basic question in Europe is whether or not we should go into manned space flight or not. It is a major question.

Senator SCHMITT. With the Ariane 5 capability, I doubt if there would be a retrieval potential for satellites launched under your auspices. But there certainly would be a repair and refurbishment possibility. Is that correct?

Mr. D'ALLEST. Yes, the accent is on robotics and automatic systems. But personally, I do think that if the system evolved, we would need a manned capability, at least for visit and repair, and this is why the studies are being done now. But it is still very controversial whether or not we should embark on such a venture.

Senator SCHMITT. Do you have any insight now, new insights, on the difficulties that you had in the early phases of the Ariane launch program, development program?

Mr. D'ALLEST. Yes. If you mean the difficulty we have with the failure of our second test flight, it is now fully under control. This is always a very tricky problem, as has been shown in the past—launch vehicles and engine development—but now it's fully under control. It costs us an expensive testing of each engine before flight.

Senator SCHMITT. You believe it was an engine problem?

Mr. D'ALLEST. It was an engine problem. It was an injection head problem, yes.

Senator SCHMITT. A what?

Mr. D'ALLEST. Injection head problem within the engine, and it is now fully demonstrated, reproduced, and the criteria for acceptance, which is the basic question for production, the criteria of acceptance of such items are now firmly established with more than 200 firings. So we now have this under full control.

Senator SCHMITT. Have you seen anything in the last two launches that you currently must work?

Mr. D'ALLEST. No. The reason is that we have demonstrated, and it was a condition before going to the third flight, we have demonstrated after full research that we could reproduce fully what has happened in the second flight in the test facilities.

So we have done a lot of work in design change and then in the acceptance criteria. We have confirmed with Ariane 3 and Ariane 4 that the spectrum analysis of the thrust chamber which was in flight was fully consistent with the one which had been approved through the acceptance variance test.

Senator SCHMITT. Well, we certainly wish you well. Bon chance, I guess is the correct expression. You're doing well and I'm sure that the Western community, commercial, and otherwise, will benefit from your efforts.

We appreciate very much your coming over and providing us with these insights. We may have a few questions for our record which we will transmit to you. You provided us an excellent background now to understand far better what the principal competitors for the Space Shuttle payload launch capability is. I think the rest of the committee will find this very valuable.

Thank you, sir.

Mr. D'ALLEST. Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF FREDERIC D'ALLEST, PRESIDENT DIRECTEUR GENERAL, ARIANESPACE

Mr. Chairman and Members of the Subcommittee, I am very honored to have been invited to testify on our ARIANE activities in front of such a distinguished assembly.

Upon the invitation of Senator Schmitt, I have chosen to offer you a short survey of the ARIANE program status, on the background and the content of ARIANE-

SPACE, our views on the launch services market and on the new and growing competition between US launch vehicles.

You are certainly aware that ARIANE 1 is a classical three-stage launch vehicle, specifically designed to launch application satellites in geostationary transfer orbit (GTO). The very modern French "Centre Spatial Guyanais" (CSG), in French Guiana, has also been selected to allow maximum use of earth rotation velocity, near-equator plane (5,5° North), in order to reach this specific orbit as economically as possible.

This, the major program of the European Space Agency, funded by 10 Western European countries, was decided in July of 1973 with an operational target of 1981. Today the flight certification of ARIANE has been officially achieved, one year following the target date, but within the financial contingency margin decided 9 years ago (116 percent instead of 120 percent). The performance largely surpassed the objectives (some 20 percent greater: approximately 1800 kg in GTO as compared with the 1500 kg project objective).

In order to enhance the ARIANE capability, an ARIANE family concept was studied as early as 1977 in order to meet the increasing size and weight of the satellites, planned in the eighties, and to meet the US launch vehicles—paricularly the STS—competition.

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We are convinced that the establishment of the ARIANESPACE company has created a healthy new situation in the launch services field. In our Western world, commercial applications in a worldwide launch service market of some 10 billion dollars (in the eighties only) means competition. I hope it will be a fair and reasonable competition.

Now that a monopoly is over, and that a challenger has appeared on the scene, I am sure that you will consider, in genuine American tradition, that this new situation will be profitable to the customers, the US and European taxpayers, the Space Agencies, and the development of Space activities.

THE COMPANY'S MAIN FEATURES

It is a French private company; incorporated on 26th March 1980; 120 million French francs joint stock; 180 million French francs total funds; 50 shareholders; 36 main European aerospace companies, 13 important European banks, and CNES based at Evry, near Paris, France.

THE COMPANY'S PURPOSES

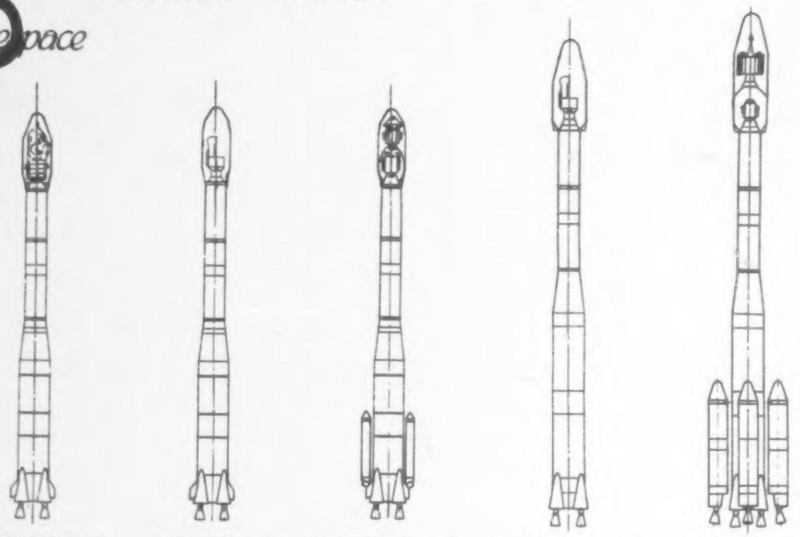
Airanespace assumes the production management; the production financing; the marketing; and the launching operations of operational Ariane launch vehicles and provides for any action related to space transport.

THE COMPANY AND ITS SHAREHOLDERS

Manufacturers.—Adtec—IR, Aeritalia—I, Aerospatiale—F, Aer Lingus—IR, Air Liquide—F, Avica—GB, B.A.D.G.—GB, C.A.S.A.—E, C.I.R.—CH, CNES—F, Comsip Entreprise—F, Contraves—CH, Crouzet—F, Deutsch—F, Dornier—D, ERNO—D, ETCA—B, Ferranti—GB, Fokker—NL, Fab. Nationale Herstal—B, F+W—CH, Intertechnique—F, M.A.N.—D, Matra—F, M.B.B.—D, Rovsing—DK, Seal-Scania—S, SABCA—B, Saft—F, Selenia—I, Sener—E, SEP—F, SFENA—F, SFIM—F, Snia Viscosa—I, Sodeteg—F, and Volvo—S.

Banks.—Algemene Bank Nederland—NL, Banque Nationale De Paris—F, Banque De Paris Et, Des Pays-Bas—F, Banque Vernes—F, Bayerische Vereinsband AG—D, Copenhagen Handelsbank—DK, Credit Lyonnais—F, Dresdner Bank AG—D, Instituto San Paol, Di Torino—I, Midland Bank LTD—GB, Societe Generale—F, Union Des Banques Suisses—CH, Westdeutsche Landesbank, and Girozentrale—D.

ARIANE FAMILY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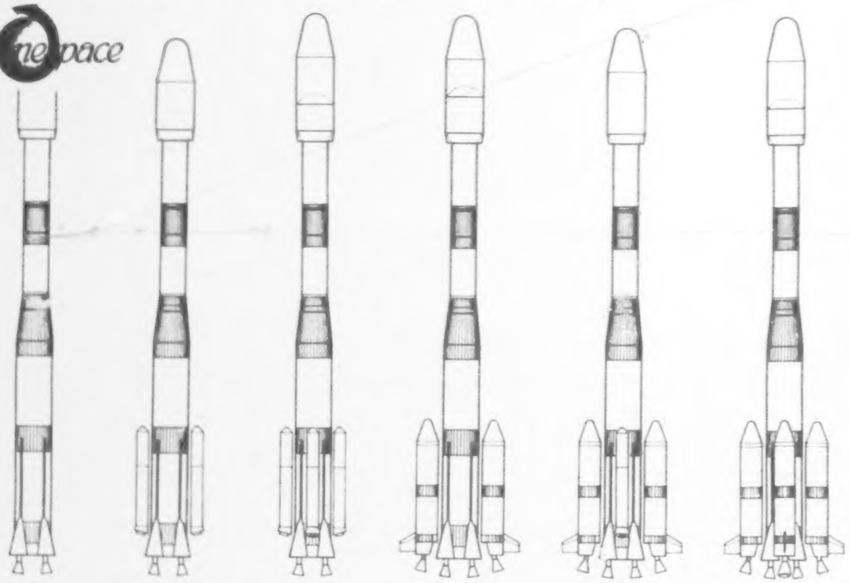
ARIANE 2
ARIANE 3
ARIANE 40
ARIANE 44L

ARIANE 4 CONFIGURATIONS


40
42P
44P
42L
44LP
44L

FIRM ORDERS AND RESERVATIONS (1).—1982–84

L5	AR.1	MARECS–SIRIO–2	April 1982.
L6	AR.1	ECS–1 + AMSAT	July 1982.
L7	AR.1	INTELSAT V F6	October 1982.
L8	AR.1	EXOSAT	December 1982.
L9	AR.1	INTELSAT V F7	February 1983.
L10	AR.1	INTELSAT V F8 or ECS–2	May 1983
L11	AR.1	ECS–2 or INTELSAT V F8	July 1983
L12	AR.2	TELECOM–1A	September 1983.
L13	AR.3	TELECOM–1B + WESTAR–VI	December 1983.
L14	AR.3	SPACENET–1 + ARABSAT–1	February 1984.
L15	AR.3	GSTAR–1 + (ECS–3)	April 1984.
L16	AR.2	SPOT–1 + VIKING	June 1984.
L17	AR.3	GSTAR–2 + SPACENET–2	August 1984.
L18	AR.3	(SATCOL–1) +	December 1984.

( ) = reservation.

From 1985 onwards: INTELSAT VA F14, TV–SAT, TDF 1, (AUSSAT 1), (SATCOL 2), GIOTTO, INTELSAT VA F15, ARIANE 4/01, (STC), (AUSSAT 2), and (ANIK–C).

Second launch pad available from 1985 onwards.

From 1986: SPOT 2, L–SAT, (CLT), (TELE–X), and (TEL–SAT).

Undated reservations: Marecs–C, ECS–4, G–Star 3, and Spacenet 3.

Note: ( ) = reservation.

Other foreseeable launches: Intelsat VI (F1 to F6), Skynet-3, CBS–DBS Corporation, ANIK series, ERS 1 and 2, NATO, Meteosat operational, SBTS 1 and 2, SAMRO, and HIPPARCOS.

ARIANE'S POTENTIAL MARKET [1].—1985—1991

	Estimated number of satellites	Part of total percent
Europe	43	24.2
U.S.A.	55	30.9
International	24	13.5
Developed countries	25	14.1
Developing countries	31	17.3
Total	178	100

[1] World except USSR, China and other Communist countries.

Senator SCHMITT. The hearing is adjourned.

[Whereupon, at 12:50 p.m., the hearing was adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1983

TUESDAY, MARCH 16, 1982

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY AND SPACE,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:45 a.m., in room 6226 Dirkson Senate Office Building, Hon. Harrison H. Schmitt presiding.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. The hearing will come to order. I apologize for getting started late this morning, but in the Defense Subcommittee we had to discuss Defense Department space investments with Secretary DeLauer, and we will have a chance to do that further in closed hearing on Thursday.

The U.S. leadership in space for the past 20 years can be attributed to a long list of items. These items include the flight of Sputnik in 1957, greatly influencing my career and the career of many others who happened to be in unusual but highly visible environments at that time. This was a major catalytic event, so to speak. Our leadership in space can be attributed to the millions of people who have been dedicated to making our programs work and work successfully, the leadership that has at times risen to meet the challenge of foreign competition and the thousands of bright ideas that people have had about our future in space and how to make it work arise from that particular time. The list is long and full of events which individually are not always important, but which fit together into a pattern of successful leadership in space.

We tend to take for granted, however, those aspects of the program that are not represented as spectacular pictures seen on TV or in the printed media, but are in fact the only thing that make such pictures possible. One such an aspect is what I call the "support elements" of our space program comprised of research and technology, construction of facilities, and tracking and data systems—the unsung heroes, really, of the space program. If it hadn't been for the dedication and motivation of individuals within those three groups everything that I and many others have accomplished would have not been possible.

We, the public, take these things for granted, often not even knowing they exist, in part because our programs have been so successful. We take them so much for granted that when Goldstone doesn't accomplish a handover lift-off from the Moon on Apollo 17 that we just proceed without you.

NASA, in the past, has strongly supported investing in facilities to support the full range of its space programs and has invested in a research and technology base to give us the option from which to choose our future plans. I fear that a major consequence of NASA's budgetary crunch over the past decade is not simply very few new program starts, but the fact that our investment in basic research and technology and in our facilities is dwindling. What that means is that our reservoir for future growth is being drained.

The work of investing in the future is not always glamorous and not easily justifiable in times of fiscal austerity. Yet, failure to make these investments over a period of time leads to increased costs, technical and safety risks and the relinquishing of our leadership position in space. This is a price that we, as a nation, should not be willing to pay. We have experienced these trends in other U.S. activities and now face increased foreign competition in domination in commercial and technology areas. That can only be resolved by either massive increases in investment or the surrendering of our market position.

If our destiny is in space, as I believe it is, I do not intend to sit by and let our U.S. dominance in this arena whither away if I can do anything about it.

Today we will examine the Office of Science Technology, the Office of Tracking and Data Acquisition, and the construction of facilities budget. I hope you will be able to give us some confidence that we are in fact securing a strong place in the future.

Our witnesses this morning will begin with Dr. Jack L. Kerrebrock, Associate Administrator of Aeronautics and Space Technology of NASA. Dr. Kerrebrock, if you would come forward. If you would summarize your prepared statement as is appropriate. We will have few questions for you.

STATEMENT OF DR. JACK L. KERREBROCK, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY, NASA

Dr. **Kerrebrock**. I will be happy to do so, Mr. Chairman.

I am pleased to appear before you today to testify for the first time as the Associate Administrator for Aeronautics and Space Technology. I am accompanied by two of my Division Directors, Dell Williams of Space Systems and Don Beattie of Energy Systems who will assist me in answering any detailed questions you may have. With your permission, I wish to briefly summarize the formal statement which is submitted for the record.

It is my view that the space research and technology [R. & T.] program should serve to maintain a technical disciplinary base not only for NASA missions but for the rapidly expanding military and commercial space efforts of this country as well. While the military and commercial segments perform applications research and development to implement technology in flight systems, it is NASA's unique role to explore at the more fundamental level the potential of emerging technologies. This responsibility dictates that the space R. & T. program address a broad range of fundamental research critical to present and future space activities and also explore opportunities for advancing the most important technologies. This breadth of activity is illustrated on figure 1 which depicts basic research in the disciplines up top and systems research on critical system elements along the bottom. All work carried out by OAST complements and supports that done by the application-oriented offices of NASA. We are endeavoring to insure that these efforts also serve the commercial and military satellite communities as well.

The space research and technology budget contains three line elements, figure 2. The budget element of standards and practices provides for agencywide support from our office of the chief engineer. The budget request of $120 million for the research and technology base and systems technology elements is 11 percent above the current fiscal year 1982 estimate, allowing for a small amount of real growth. Our strategy for best utilizing these critical resources has been described in previous years' testimony as giving the highest priority to the basic work carried on in the R. & T. base, $115.6 million. Over the past decade, this prioritization has resulted in a lower level of effort in the systems technology element where the objective is to bring technology to the state where it can be considered suitable for application with moderate risk. It should be recognized that this function must be provided by other NASA program offices, by the military or the commercial sectors if it is not conducted as part of the space R. & T. program.

As shown on figure 3, the Ames, Langley, and Lewis Research Centers now report to my office. Having the institutional responsibility for the research centers permits my office to formulate and manage the construction of facilities [C. of F.] and the research and program management [R. & P.M.] budgets as well as the aeronautics and space research and development [R. & D.]. The magnitude of this support is indicated in figure 4, shown at the right the total program resources supporting the space technology budgets are $213 million for fiscal year 1983.

These resources are dispersed among the research centers and flight centers of NASA in the proportions, shown on figure 5, which also depicts the technical emphases at each center. The spectrum of capabilities provided by the research and flight centers provides a balance in both the disciplinary work and in applications-oriented tasks.

I should like now to selectively describe some of the programs for fiscal year 1983, some accomplishments of this past year, and how our programs support our planning goals. Of particular note this year, there are the many OAST space flight technology experiments that have been flown and the many others being readied for future flights. Due to the shortness of time, I will describe only the flight experiments. Although these experiments represent only a small fraction of our program, the current results are important milestones in a long-term effort of which we are extremely proud.

The Space Shuttle provides an unprecedented opportunity to obtain flight research data on the performance characteristics of a space transportation vehicle, data which is unavailable from simulations in ground test facilities and which is essential to a full understanding of Shuttle performance and to the validation of design tools. With the successful *Columbia* flights, we, in OAST, had a special sense of pride because of the many contributions we feel we have made to its development. Prior to initiation of the development, our office managed extensive efforts in advanced technology and design activities supporting this national venture.

Our earlier work on aerodynamics, propulsion controls, power sources, materials, and structures provided important inputs to the final design and ultimate success of this vehicle. For example, aerodynamic test facilities in the research laboratories were utilized in excess of 60,000 hours in design and development testing prior to flight. Our inventions of thermal protection systems, their coatings and installation methods, were crucial to the successful reentry performance of the vehicle. Our work on advanced propulsion technology laid the foundation for the high pressure hydrogen oxygen engine which provides thrust from lift-off to near orbit insertion.

In addition to these contributions to the development of the Shuttle, we are pleased to have conceived and implemented a flight research program that affords investigators an early opportunity to better understand Shuttle performance and environments. Our orbiter experiments program [OEX] provided instrument packages which flew on the first and second Shuttle flights as well as several that are planned for future flights.

The aerodynamic coefficient identification package [ACIP] was developed as part of the orbiter experiments program to acquire precise flight dynamic data and assess the aerodynamic characteristics of the vehicle. Using STS-1 entry data obtained in this experiment, it has been possible to determine the source of an unexpected vehicle oscillation and to provide vital corrective measures for future flights.

On the STS-2, we incorporated two additional orbiter experiments to investigate catalytic surface effects in tile gap heating. From the results of this highly successful experiment, we have concluded that standard Shuttle tiles do not behave catalytically and, therefore, experience less severe heating than expected. Future flights can function under more severe entry conditions.

The other experiment provided the first research quality flight data on the effects of tile gaps and adjacent radii. All three of these orbiter experiments will be continued in future flights. In addition, new experimental packages will be added in fiscal year 1983.

An especially instrumented nose cone will provide aerodynamic data at altitudes below 30,000 feet. A mass spectrometer will be added to provide data at higher altitudes. An infrared sensor will be mounted on a special tail pod on the orbiter to give upper surface temperature measurements.

In addition to the orbiter experiments I have described, we were early users of the Shuttle as a platform for conducting other technology experiments. One of these was the feature identification and location experiment [FILE]. Its purpose is to spectrally sense and qualitatively assign the Earth surface to four classes: vegetation, bare earth, water, and cloud cover snow and ice. Real time, onboard image classification was achieved for the first time on STS-2. A reflight of this experiment is planned on OSTA-3 to gather statistical data and improve the Sun angle. This experiment in supporting laboratory results are all designed to reduce the cost of data processing by allocating more of the job to onboard systems.

The induced environment contamination monitor program was initiated in response to user concern about STS contamination to optics, solar cells, and heat transfer surfaces. The monitor is a composite of 10 instruments that measure the STS environment during all phases of Shuttle operation from preflight through postflight. Installed in the orbiter payload bay the equipment was successfully flown on the STS-2 mission. The results are encouraging with preliminary indications that contamination levels are within goals. STS-3 and STS-4 missions are planned for longer duration. In fiscal year 1983 the instrument will also be carried on STS-10, the first Spacelab mission.

One upcoming flight experiment in fiscal year 1983 will be launched by the Shuttle aboard the Air Force Teal Ruby spacecraft. This is the ion auxilliary propulsion system experiment [IAPS]. The flight test article of the IAPS is currently in final system test. This thruster system is suitable for North/South stationkeeping of geosynchronous military and commercial communication satellites. NASA is scheduled to deliver the flight hardware this spring for integration into the spacecraft, which is scheduled for launch in 1983 under an interagency memorandum of agreement.

More such opportunities are being sought for cooperative efforts between NASA and the military. In the latest NASA/USAF interdependency meeting held this past January, teams of experts assessed high priority mutual technology interests derived from the NASA and a military space system technology models. Formal memoranda of agreement either already exist or are being generated for exchange of data in some 25 activities. Efforts are proceeding to select a half dozen for intensive jointly planned and conducted programs. The product of this interactive process will be a NASA space research and technology program that serves as a national resource.

To summarize, I wish to underscore my conviction that this technology program will generate high quality additions to the agency's reservoir of space system design options. It provides for less systems research than was projected in last year's authorization testimony; but, it represents what we consider to be a judicious application of scarce resources.

Mr. Chairman, I would like to close with a few words about our activities in support of the national energy programs. Although in the past there has been NASA funded energy work, we are not requesting funds for this purpose. Our energy involvement now consists of supporting DOE and other agencies on a reimbursable basis by conducting energy research and technology. These efforts have been underway for approximately 10 years; progress has been made in many important technology areas. Just a few examples of the technology areas we have been supporting over the past years are large wind turbine development, photovoltaic systems, fuel cells, and advanced heat engines including automotive gas turbine and Stirling engines. Industrial involvement in these programs has been an important key to the accomplishments that have been made.

With continuing reductions in civil service manpower, these efforts detract somewhat from our ability to carry out our responsibilities for aerospace research. We have attempted to minimize this impact by choosing areas of activity which produce technology advances of potential benefit to aeronautics and space. However, as we look ahead we find it will be necessary for NASA to phase out its reimbursable civil service manpower support to energy by the end of fiscal year 1983 in order to more appropriately devote the available manpower to our traditional programs.

The Jet Propulsion Laboratory will continue to provide support to energy areas where they have the capabilities required to successfully accomplish program goals. I want to assure this subcommittee that we will structure this transition in coordination with the sponsoring agency such that the investments that have been made will be protected and an efficient transition to new management will be carried out where appropriate.

That concludes my testimony.

Senator SCHMITT. Let's don't rewrite history. NASA got into the energy thing because it wanted to. I was there. Don't say it was because Congress ordered it or because DOE requested it, or anything like that.

NASA wanted it under Jim Fletcher; NASA wanted to get into energy research and technology. And we did. I know because I led the effort.

Dr. KERREBROCK. Yes, sir.

Senator SCHMITT. So I hope you will submit a revised page that clearly reflects the history and doesn't put that burden of that decision on other agencies.

It was a conscious correct decision, in my opinion, on the part of NASA.

Dr. KERREBROCK. Yes, sir, my prepared statement will be changed to clarify that.

Senator SCHMITT. And if it is a conscious decision on the part of NASA to get out, let's say that. OMB didn't order it. NASA decided to get out.

Dr. KERREBROCK. Yes, sir. I will say, though, that the decision made by NASA was at least in part stimulated by the perception that the DOE budget in support of these programs was——

Senator SCHMITT. There wasn't a DOE when NASA made that decision.

Dr. KERREBROCK. I am responding to the last question, which was whether NASA made a deliberate decision to withdraw from energy in fiscal year 1983. The answer is that the position that has been taken by Mr. Beggs is that we are withdrawing because the DOE does not have in its budget funding for these programs in fiscal year 1983.

Senator SCHMITT. We will see what happens when the DOE budget is finally acted upon by the Congress. I do not agree with NASA's decision that there is no role for NASA in energy research and technology that basically takes the technology base, developed for space flight, and attempts to refine and expand that base so it can be used in more efficient end use of energy.

That was the basis of the program when we started. It had nothing to do with the existence of DOE. It had nothing to do with the existence of any agency other than NASA and its associated industries who had something to offer in conservation and end use efficiencies.

That decision was made by NASA. It was supported by the Congress. It was supported by agencies who had other missions as they came into existence or as they expanded those energy missions. But don't put the blame on anyone other than NASA for changing their mind on this decision, unless you want to say that because of budget cuts in other areas NASA can no longer afford this kind of activity based on its total priority analysis. That argument you might make—not that I think it is the correct decision on the part of the OMB and of the administration, but it is at least an argument that NASA can live with.

Dr. **KERREBROCK**. The reason I gave was the reductions in civil service manpower.

Senator **SCHMITT**. I recognize that. But don't say NASA didn't get into this willingly. That is the implication of your statement.

Dr. **KERREBROCK**. We will correct that.

Senator **SCHMITT**. How has support for technology development changed over the past decade in terms of the total NASA budget.

Dr. **KERREBROCK**. It has decreased. The fraction of the NASA budget which is devoted to the space technology program has decreased. If you would like the exact numbers I will ask Mr. Williams to respond.

Mr. **WILLIAMS**. The fraction of the NASA R. & D. budget devoted to space technology has decreased from about 3.5 percent in 1970 to about 2.2 percent of the fiscal year 1983 budget as presented to the Congress this year.

Senator **SCHMITT**. How does that compare with what a major technology based U.S. corporation would expend?

Mr. **WILLIAMS**. I believe that is somewhat variable. As I have talked to leaders in industry, they find it very difficult to come up with a percentage. But a representative number which was given by one of our major contractors was about 4 to 5 percent which was considered to be the average in the industry.

Senator **SCHMITT**. Has that changed in the past decade, do you know?

Mr. **WILLIAMS**. In the last 5 years, the R. & D. investment by the industry has also started on a downturn; so, it probably has decreased. I really don't have very current numbers.

Senator **SCHMITT**. Aren't there indications that industry is beginning to turn that around as a result of both their needs and the Tax Code reforms that were put into place last year?

Mr. **WILLIAMS**. I think there has become an awareness of the need to turn that around. Some of the tax legislation has encouraged that in the industry, and my guess is that it is on the upturn again.

Senator **SCHMITT**. Could you provide for our record a comparison of those percentages to the best of your ability for the last decade?

Mr. **WILLIAMS**. Yes, sir.

Senator **SCHMITT**. I think you will find when you look at that and look at a company like GE or TRW or others that the investment over the last 5 years may have actually shown an increase rather than a decrease.

Mr. **WILLIAMS**. We will provide that data.

[The following information was subsequently received for the record:]

The NASA investment in space technology has been declining for many years. While some of this decline has simply been a reflection of reduction in spending power of the total NASA budget, it must be recognized to be more than just a proportional share. Expressed in FY 1982 dollars, the Space R&T budget in FY 1970 was in excess of $300 million while in the proposed FY 1983 budget it is $120 million, equivalent to about $110 million in FY 1982 dollars. This is a drop from 3.9 percent to 2.2 percent of the Agency R&D budget. It should be noted that the FY 1970 figure has been reduced to exclude any budget assigned for nuclear research being conducted at that time so it is on a valid basis of comparison. An even more dramatic percentage loss is reflected in the manpower assigned to the NASA advanced Space R&T activities. In FY 1970 about 3300 or 15.1 percent of the Agency's direct manpower was assigned to advanced Space R&T but by FY 1982 the number had declined to 1383 which is only 8.4 percent.

This trend to cutting back on research investment when budgets get tight is not unusual and unfortunately occurs in other Government, business, and even academic sectors. It is extremely difficult to extract comparable data because of the highly judgmental and sensitive nature of what constitutes research; but most progressive organizations that have successfully exploited research contend that the 5 percent level constitutes an appropriate basis. With much of the aerospace industry expanding their military sales, they have been able to increase their allowable overhead contribution to IR&D. This provides visible improvements in the industrial contribution to the Nation's Space R&T needs.

Dr. KERREBROCK. Mr. Chairman, I would like a clarification on that as to the categories that you have in mind. The budget we are talking about here is the space technology budget of an R. & D. agency.

Senator SCHMITT. But it is the budget, it is the basic sustaining R. & T. budget of the agency.

Dr. KERREBROCK. I think that the numbers that Dell Williams is referring to are the R. & D. budgets of production-oriented organizations. Therefore, the comparison is not necessarily very straightforward, since NASA is essentially an R. & D. agency.

Senator SCHMITT. But it is a production agency. You are producing a product. You are producing Space Shuttles, you are producing spacecrafts for national activity. The question is, What is the R. & T. base that sustains that effort for the future.

Dr. KERREBROCK. I see.

Senator SCHMITT. GE builds engines, GE does other things, and they have a sustaining R. & T. base of some proportion to their total corporate activity.

Dr. KERREBROCK. You would like the basic research component of that corporation's effort?

Senator SCHMITT. Basic research and technology. That is a distinction that you make in NASA and I think it is a good one, that there is something different between research and technology and what is normally thought of as research and development. That has been the raison d'etre of your organization, not only in NASA but when it also existed within the NACA; build that reservoir of technology from which you are able to do research and development of actual hardware.

Dr. KERREBROCK. Right.

Senator SCHMITT. Do you agree with that view of the role of the Office of Space Technology within NASA?

Dr. KERREBROCK. Yes, sir, I do. In fact, I view the role of the space technology program in my office as being to provide the base technology in space for the Nation; that is, for NASA missions, for the commercial, and for the military sectors as well.

Senator **Schmitt**. Do you think NASA ought to be undertaking research and technology activities that serve the commercial sector, or is that something that ought to be done by the commercial sector?

Dr. **Kerrebrock**. I believe that NASA should provide that role in the basic areas of space technology.

Senator **Schmitt**. Do you see a role of bringing the industrial entities, governmental entities and academic entities together in one place where these technology developments can occur under a protective umbrella immune from antitrust laws and other inhibitions that prevent that from happening in the private sector?

Dr. **Kerrebrock**. Yes, sir, I think that NASA should fulfill the function of providing a national coordinated focus, in addition to a technical base for the whole national community. That is quite an analogous way to the aeronautics program, the aeronautics R. & T. program which has been the underpinning of the whole aeronautical industry of the United States.

Senator **Schmitt**. That's all right. We are going to take those underpinnings out also. Don't you feel though that there are some activities because of the existence of antitrust laws that just can't happen within the commercial sector, and that NASA can play a role in providing a legal means by which there can be coordinated research and technology that benefits the Nation, not just one company?

Dr. **Kerrebrock**. Sir, I am not sure how much of a limitation there is because of the legal constraints, but I am quite clear in my mind——

Senator **Schmitt**. Well, GE and other engine companies can't join together by themselves in order to develop some components, new technology that would enhance certain components of a jet engine. They can do it when they work with NASA and have done it for decades, but they couldn't do it if they try to do it alone. Is that not correct?

Dr. **Kerrebrock**. I was responding to the question about space technology.

Senator **Schmitt**. I am just asking you, isn't the analogy the same?

Dr. **Kerrebrock**. I think it is; yes.

Senator **Schmitt**. In Comsat and TRW and A.T. & T. and to sit down independent of NASA and work on basic research and technology to enhance our communications capability? I think the answer is no; they can't do that. You may want to provide an answer for the record, but I believe it is correct to say that NASA does provide a legal means by which they can work together with NASA, with academia in order to enhance our national technology base without fear of prosecution under antitrust.

Dr. **Kerrebrock**. Yes; I think that is probably true. I was responding to some other reasons for this or giving you other reasons which are several. One is the shortage of technical manpower that is available to do this kind of work which dictates that there be a pooled effort in the area of space technology.

[The following information was subsequently received for the record:]

As stated in my testimony, there appears to be a potentially strengthened coordinating role for NASA in serving total national needs for research in advanced technologies. Consistent with the Agency and Administration policy in the Space R&T program, we are not proposing to address research and development of flight systems, and certainly not flight demonstration programs. The research and technology under discussion is at the level of: exploring the application of science and engineering phenomena; the innovation of new hardware and software capabilities; the development of design and laboratory test tools and techniques; and, the maintenance of a nationally recognized cadre of skills and facilities to maintain U.S. preeminence in space. The cadre would be drawn from Government, industry, and academia. Chairman Schmitt's comment regarding NASA's ability to operate in a legal framework in providing leadership and coordination is certainly compatible with our stated intent. This proposed role is similar to that served by the NASA Aeronautics R&T program which has been a successful forerunner of flight programs by introducing new technology which can be incorporated into production aircraft.

The previous focus of Space R&T heavily emphasized support of future NASA space flight programs. With total national space involvement increasing in scope and its impact on the economy, political events and national security, it is appropriate to examine a shift in the role of our Space R&T program. We are exploring the impact of this policy issue with our various advisory groups and will report to you as progress is made.

Senator SCHMITT. Oh, there are all sorts of good reasons.

Dr. KERREBROCK. Another reason is the difficulty in funding long-term basic research in the private sector.

Senator SCHMITT. But none of them are necessarily show stoppers as is the legal prohibition against coordinated research and development. Although I agree with those arguments also; I think they are equally valid. It is just that somehow or another this administration feels that the industry can go out and develop and do a lot of things on their own that they have been doing in cooperation with NASA. Frankly, that is just not true, unless we change some very basic legal restrictions on coordinated research and development within industry.

Do you feel that the intensity of interaction between NASA and the Air Force is sufficient for the present in the area of technology planning?

Dr. KERREBROCK. Yes, sir. I believe that interface has worked pretty well. We are continuing to give it emphasis. We feel that we are quite well coordinated with the military programs.

Senator SCHMITT. There is some suggestion in the view from the Hill that NASA and Air Force coordination in other areas has resulted in a dividing up the pie rather than cooperation.

Dr. KERREBROCK. I think it is important that we not duplicate each others efforts.

Senator SCHMITT. There is no value in duplication at times?

Dr. KERREBROCK. I believe that in base technology work, where the resources are very limited we really can't afford to duplicate in the strict sense of the word. So, it is important that if the Air Force is supporting a program, NASA not duplicate it directly. There is too much to be done. There is so much work to be done that the funds are saturated so that doing the same thing in two different programs I think is inadvisable. From that standpoint, coordination is all important.

Senator SCHMITT. What about coordination of the actual work going on?

Dr. KERREBROCK. That is what I am referring to, sir.

Senator SCHMITT. Not to avoid duplication, but to make sure that the projects are serving both a civilian and a defense community?

Dr. KERREBROCK. Yes. Of course, at the base technology level, it is much more likely that a given project will serve both ends than it is at the applications level. The work that we are talking about here is at the base technology level primarily.

Senator SCHMITT. What is the mechanism of interaction?

Dr. KERREBROCK. We have the NASA/Air Force interdependency group which meets quite frequently. In addition to the formal coordination mechanism, there is a good deal of interaction between the working people.

Senator SCHMITT. Are you able to monitor that in any quantitative way, that interaction?

Dr. KERREBROCK. Quantitative?

Senator SCHMITT. Yes. How do you know whether or not a researcher at Lewis is coordinating in the appropriate way with colleagues within the Air Force establishment, Wright Patterson, someplace like that.

Dr. KERREBROCK. We do that in a semiquantitative way by assessing the researcher's knowledge of the Air Force programs. I am sure the Air Force does the same thing. In addition, we have formal review meetings and parallel space technology models. NASA has a set of documents which are described as the space technology model giving the requirements and the state of technology in areas directed toward these requirements. As a result of that NASA initiative, there is now a parallel military space technology model which can be compared with the NASA model.

Senator SCHMITT. Model?

Dr. KERREBROCK. It is a document describing requirements and programs. The term "models" is just our way of describing that.

Senator SCHMITT. Is there a basic research organization for space technology within the Air Force that parallels your organization?

Dr. KERREBROCK. No; sir, there is not. There is interest in supporting space technology work at the very basic level, the 6.1 level in AFOSR. But, I believe it is fair to say that there is no organization within the Air Force that has a directly parallel responsibility to mine in that it goes all the way from basic research through the technology.

Senator SCHMITT. It is my understanding that there really are no 6.1 or 6.2 level projects funded by the Air Force, is that correct?

Dr. KERREBROCK. No, that is not quite correct, because there is some space work funded from AFOSR. That work is a relatively recent development, but there is some now. Of course, there are development programs. In some people's perception there is a gap between those two in the Air Force.

Senator SCHMITT. Is that your perception?

Dr. KERREBROCK. Yes, sir.

Senator SCHMITT. Is there any significant Air Force sponsored research and technology in areas related to manned space flight relative to those related to automated spacecraft?

Dr. KERREBROCK. Let me check that with Mr. Williams. I don't think so.

Mr. WILLIAMS. Mr. Chairman, there has not been much activity except at a study level in the Air Force until rather recently. Recently, there is an interest in assessing an alternate manned space flight capability which primarily centers around launch vehicle and some transfer vehicle capability at a rather basic level. The activity is at a study level and is directed out of the Space Division which is assigned to Wright Patterson-flight dynamics laboratory.

Senator SCHMITT. Paperwork?

Mr. WILLIAMS. Paperwork.

Dr. KERREBROCK. It is the study of a potential system. The reason I hesitated is because I am not sure; but, I think, there probably is some work in the human factors area being done at the Air Force Human Factors Laboratory, which impinges on space.

Senator SCHMITT. But would it be safe to say that whatever interest the Air Force may have in research and technology now related to manned space flight, not in the development of transfer vehicles or anything like that, but in basic research and technology, that the Air Force looks to NASA to perform that R. & T. rather than investing in themselves?

Dr. KERREBROCK. Sir, I believe the way I would put it is that the Air Force posture toward manned space activity at the present time is not as highly developed as NASA's.

Senator SCHMITT. That is the understatement of this hearing, I suspect. So based on what you see, the Air Force activity is consistent with the Secretary of Defense's statement of a few months ago that the Space Shuttle—and I interpret that to mean manned space flight—is not a high priority within the Department of Defense?

Dr. KERREBROCK. I believe that as a launch system for Air Force missions, the Space Shuttle has a fairly high priority.

Senator SCHMITT. Not according to the Secretary of Defense and apparently not according to the Secretary of the Air Force. I don't expect you to be able to read these minds, but their statements in the paper indicate that it is not a particularly high priority, although they would be happy to come over and operate it for NASA.

Dr. KERREBROCK. The Department of Defense, the Air Force in particular, is making a very significant investment in launch facilities at Vandenberg for operations of the Shuttle.

Senator SCHMITT. So you would say that we do have a national coordinated program for space technology?

Dr. KERREBROCK. Yes, sir.

Senator SCHMITT. Subject to improvement but nevertheless contributing something worthwhile?

Dr. KERREBROCK. I believe that is correct.

Senator SCHMITT. If there were one thing you could do to improve it, what would you do?

Dr. KERREBROCK. I would like a recognition for NASA's role in space technology as I described it, which is as the agency which is responsible for the base technology for the country.

Senator SCHMITT. Are there any joint technology programs now specifically funded by both the Air Force and NASA, or DOD and NASA?

Dr. KERREBROCK. We have many cooperative programs. If by "joint programs" you mean ones in which we each put in part of the money, I think there are a few. Dell, would you like to comment on that?

Mr. **Williams**. Mr. Chairman, we have a large number of cooperative technology programs. Most of them are attempts to pursue two alternate approaches in a coordinated fashion.

Senator **Schmitt**. Could you provide us for the record a list of those programs?

Mr. **Williams**. Yes, sir.

Senator **Schmitt**. And funding levels as you understand them on both sides?

Mr. **Williams**. Yes sir.

[The following information was subsequently received for the record:]

The following technologies have been identified as areas of mutal interest between NASA and the Air Force. These result from a joint agency working committee. Principal investigators from both agencies maintain contact for purposes of information exchange planning coordination, and, where feasible and desirable, possible future joint efforts. Several of these joint activities are formally documented by Memoranda of Agreement (MOA).

1. Aeromaneuvering
2. Automated Spacecraft Maintenance
3. Brayton Cycle Energy Conversion
4. Chemical Propulsion Research
5. Composite Material Antennas
6. Computer Mediated Teleconferencing
7. Infrared Detectors and Sensors
8. Dynamic Control of Large Space Structures
9. End-to-End Data Systems
10. Space Environmental Effects (MOA)
11. Platform Systems
12. Fiber Optics
13. Gallium Arsenide Solar Cells
14. Ion Auxiliary Propulsion
15. Large Optics
16. Laser Fiber Optics Gyro
17. Lithium, Nickel-Hydrogen, and Nickel-Cadium Batteries
18. Near/Submillimeter Wave Technology
19. Star-tacker for Autonomous Navigation and Attitude Reference
20. Onboard Data Processing (MOA in process).
21. Radiation-Hardened Electronics
22. Satellite Communication at X-band and at 30/20 GHz (MOA)
23. Dynamic, Acoustic, and Thermal Environment data for Shuttle Payloads
24. Solid-state Mass Memory Devices (MOA)
25. Particulate Contamination in Space Environment
26. Space Charging in Orbital Plasma Environment
27. High Power Spacecraft Environmental Interactions
28. Traveling Wave Tube (TWT) Failure Analysis (MOA)
29. Computer-aided Design, Manufacturing, and Test
30. Teleoperated Maneuvering for Space-based Operations
31. Deployable Large Antennas

These technologies cover about 30 percent of the NASA Space R&T program (approximately $40 million). Without having complete Air Force data, we would only estimate that their funding for these efforts would be of somewhat smaller order.

There are two programs receiving joint funding from NASA and the Air Force under single, unified contracts: "Archival Mass Memory for Computers" under item 24, and "30/20 GHz Traveling Wave Tubes" under item 22. NASA funding is $1.80 million and $697,000 respectively on each of these. Air Force funding is, correspondingly, $1.84 million and $270,000. Under item 28, a "Traveling Wave Tube Technology Improvements" program provides for Air Force procurement of prototype devices and subsequent NASA testing to be coordinated through the MOA process. NASA testing is conducted by the Lewis Research Center for the Air Force on a continuing basis. Items 10 and 20 have MOA's which formally establish coordination terms of reference and parameters to be addressed.

Senator **Schmitt**. What proportion of the space technology research in NASA is done in-house?

Dr. **Kerrebrock**. About 50 percent.

Senator **Schmitt**. Is there any reason to continue this in-house effort? Could it not be done by contract?

Dr. **Kerrebrock**. Yes, sir, I think there is a very strong reason to continue it and even expand it, which is to provide that in-house capability which is necessary for a national focus on space technology in NASA.

Senator **Schmitt**. You are saying that there is a proven value to having expertise in-house rather than contracting for it as the need arises?

Dr. **Kerrebrock**. I believe it is absolutely essential to have a very strong in-house expertise both for providing advanced research capability and also for performing judgments on new programs as they arise, providing advice and deliberation.

Senator **Schmitt**. Is there any value to being able to independently assess contractor performance or proposals prior to performance?

Dr. **Kerrebrock**. I think so. That is what I mean by providing advice to the funding agencies.

Senator **Schmitt**. No way to quantify the value of that in-house effort, is there, in terms of what it contributes to cost savings in programs that are in fact contracted out?

Dr. **Kerrebrock**. It is very difficult because it is almost impossible to assign a cost to a mistake you didn't make. It is very easy to put a price on the mistakes that you do make. But the value of in-house expertise is in avoiding mistakes. However, there is no way really to figure out after the fact what it would have cost you if you had done it wrong.

Senator **Schmitt**. Can you think of any examples of where the absence of an in-house R. & T. effort may have contributed to a mistake?

Dr. **Kerrebrock**. I could give you an example from the Shuttle where the in-house expertise on the thermal protection system at Langley and Ames Research Centers contributed enormously to the success of the Shuttle operation.

Senator **Schmitt**. To take a very specific aspect of that, was the NASA effort inadequate to anticipate the problems seen on the last flight where apparently moisture absorption on the pad caused the loss of tiles during reentry?

Dr. **Kerrebrock**. I think that is the kind of difficulty that one more or less expects to arise in a major technology development program such as the Shuttle.

Senator **Schmitt**. But clearly a comprehensive test program on thermal protection materials would have analyzed their absorptive characteristics as well as their characteristics under intense and rapidly rising thermal stress.

Dr. **Kerrebrock**. I think it did, if I understand correctly. The reason is that the tiles have a glass coating on them. The difficulty is that cracks develop on that coating. I think that is the kind of thing that you would expect to arise in a high risk development program such as the Shuttle represents.

Senator **Schmitt**. But the idea of an R. & T. effort is to minimize those. Is this one that could have been minimized out of the program with a more extensive R. & T. effort on the part of Langley or other centers?

Dr. KERREBROCK. It might have been, yes. My own judgment would be that one could not expect to eliminate all such risks.

Senator SCHMITT. I am not suggesting that you can. But you did have to make decisions in the R. & T. effort in support of the Space Shuttle program on what you thought would be the most likely problem areas and you funded those and worked in those areas to the inclusion of others where professional judgment correctly, in most cases that I am aware of, said these are not high probability problem areas and therefore we will take the risk of not working them?

Dr. KERREBROCK. Yes, sir. You understand that the tiles are waterproofed with a material which is somewhat volatile so that it vaporizes during the heating of reentry. So then it is a question of rewaterproofing.

Senator SCHMITT. Do you feel that the current funding level if projected out into the next few years is going to enable NASA to maintain its in-house capabilities to adequately monitor contracts and evaluate proposals? I should add there, not just contracts and proposal evaluation, but the evaluation of changes during the contract period?

Dr. KERREBROCK. The program as we have designed it represents a very sound program which will provide a lot of capability. It is a well-balanced program. There are certainly many things that we could do to provide additional capability. There are parts of the engineering scientific community in the United States that we could draw on that we won't be able to draw on. It is the nature of a space R. & T. program such as this that there are always far more opportunities than we can take advantage of, so that certainly a higher funding level could be well used.

Senator SCHMITT. But if we cut your program in half from what has been proposed you would still probably say the same things, right? Or if NASA cut it in half, or if OMB did, you would have to testify to the same——

Dr. KERREBROCK. No, sir, I think if the program were half the present size, I would say that it would be inadequate to support the in-house capability and the institutional base that we need.

Senator SCHMITT. Well, your disadvantage is that there is no way to quantify how much is enough when you are doing research and technology?

Dr. KERREBROCK. That's right, except that below a certain level, the program would be inadequate to support the size of the establishment that we have in the research centers and in the flight centers. Further reduction in funding would imply a reduction in real level of competence in those centers.

Senator SCHMITT. Could you provide for our record an assessment of Soviet space research and technology effort. If it needs to be classified, it can be made classified for our purposes?

Dr. KERREBROCK. Yes, sir.

Senator SCHMITT. And how do you think we stack up relative to that effort?

Dr. KERREBROCK. Yes, sir. We can try.

[The following information was subsequently received for the record:]

While NASA considers it important to maintain an awareness of the state-of-the-art in space research and technology, only those nations that freely publish and exchange such data are known directly to us. We would be happy to work with the Senate staff in identifying the proper government source for this information.

Senator SCHMITT. Well, you can talk between the staff and see what we can work out and what might be useful to us, if anything.

Finally we will have a number of questions for the record, but if you look ahead to the early part of the next century, what do you think the greatest R. & T. needs are relative to propulsion technology in space?

Dr. KERREBROCK. It is clear that we need a fairly extensive effort on what we call orbital transfer vehicles. I believe that the electric propulsion system will be required for advanced missions in that timeframe as well as some sort of high power to weight ratio nuclear power system.

Senator SCHMITT. Could you provide for our record, indications of the nature and value, funding levels of programs that you have in cooperation with the Los Alamos National Laboratory and the Sandia Laboratory on nuclear systems for use in space, both for electric power and propulsion?

Dr. KERREBROCK. Yes, that is the SP-100 program, as you know. I will provide that.

[The following information was subsequently received for the record:]

The principal effort NASA has that involves Los Alamos National Laboratory is research aimed at space nuclear reactor power systems. Such systems are expected to have value in potential civil and military missions in the 1990's which demand high power, 100 kW or more. These missions include, for example, propulsion for planetary exploration and power for advanced communications, surveillance, future space platforms, operation in the Van Allen belts or under conditions of solar occlusion. In prior years, NASA has funded high temperature heat pipe research in this area at Los Alamos.

During FY 1982, we have reached tentative agreement with both DOD and DOE to embark on the joint SP-100 program which is aimed at establishing the critical technology base for space nuclear reactor systems. The planned funding level for this activity is $6.2 million in FY 1982 and $10.4 million in FY 1983.

These funds cover work being done within NASA, DOD, and DOE, the latter principally at Los Alamos National Laboratory.

In one other effort, NASA has supported a high velocity rail gun feasibility investigation at Los Alamos National Laboratory at a level of $30,000 in FY 1982. We are not funding work at Sandia on nuclear systems at the present time.

Senator SCHMITT. Do you have a continuing effort in radio isotopic thermoelectric generators with Sandia.

Dr. KERREBROCK. We are continuing to acquire radio isotope thermal generators for the Galileo mission, for example.

Senator SCHMITT. But is there any new research and technology effort in this area?

Dr. KERREBROCK. Only on the energy conversion system, so far as I know, not on the heat source. The heat source is, of course, DOE's responsibility at the present time. The conversion system is NASA's responsibility. We do have a continuing effort on that.

Senator SCHMITT. I would hope DOE is designing to some requirements provided by NASA?

Dr. **Kerrebrock.** Yes, sir. But you asked if there was continuing R. & T. To my knowledge, it is a production program at the present time for those sources.

Senator **Schmitt.** Do you mean in—you mentioned OTV, Orbiter Transfer Vehicle effort. Would you be more specific on what is underway?

Dr. **Kerrebrock.** I referred to low thrust and, in fact, variable thrust high specific impulse chemical rockets for transfer from lower orbit to geosynchronous.

Senator **Schmitt.** Do you think that the technology base is such that it would be appropriate, that we could now or in the very near future begin a competitive procurement of an advanced orbiter transfer vehicle beyond the high energy upper stage controversy that currently rages?

Dr. **Kerrebrock.** Yes, sir, beyond the Centaur or the RL-10 technology. There is a significant technology advance possible.

Senator **Schmitt.** We are ready, if there was a decision to proceed, we are ready from a technology point of view to enter into phase B design studies leading towards a contract for procurement?

Dr. **Kerrebrock.** I believe so, yes.

Senator **Schmitt.** How quickly do you think such a vehicle could be developed and procured?

Dr. **Kerrebrock.** I wouldn't want to give you a schedule for that without deliberating a little bit. If we could offer that for the record, I would prefer it.

[The following information was subsequently received for the record:]

A distinction needs to be made between a high-energy upper stage and an advanced orbital transfer vehicle (OTV). In the context of the testimony, a high energy upper stage is a near-term complement to the IUS to be available in the late 1980's. The procurement for such a vehicle could be initiated today and it would reflect the currently existing technology base. Such a vehicle would necessarily be expendable and would be capable of delivering a payload in excess of 10,000 lbs to geosynchronous orbit (GEO) from the Shuttle. The principal issue is to adequately define the capabilities for such a stage to meet the needs of DOD, NASA, and commercial missions.

Your question addresses the advanced OTV and we are currently funding programs to develop a technology base for this vehicle that we envision could become the operational "work-horse" in the mid-1990's, both in an unmanned and manned configuration. The key characteristics of an advanced OTV are performance, operational flexibility and life, which includes the capability to reuse and space-base the vehicle. Critical technologies include: aero-assisted recovery of a vehicle returning from GEO; an advanced LOX/LH_2 propulsion system with high performance; throttleability down to 10 percent of rated thrust, multiple starts, and long-life; space maintainable components; tankage suitable for long-term storage of cryogenic fuels and compatible with the space-debris environment; and, the management and transfer of cryogenic fuels in zero-g. The procurement of this vehicle could not be initiated today—the technology is not yet available. Our technology goals are aimed at a late 1980's start for an advanced OTV which would be available in the mid-1990's.

NASA has conducted conceptual studies for an OTV, which in the early configurations satisfies the 10,000 lbs to GEO requirements for a high-energy upper stage and which could evolve into an advanced OTV meeting those characteristics listed above. This evolutionary growth capability should be an important part of our upper stage planning.

Senator **Schmitt.** Yes, you may. And we will have some other questions for the record. Thank you very much. We appreciate it. We must move on.

[The statement follows:]

STATEMENT
of
Dr. Jack L. Kerrebrock
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Science, Technology and Space
Committee on Commerce, Science and Transportation
United States Senate

Mr. Chairman and Members of the Subcommittee:

I am pleased to represent the Office of Aeronautics and Space Technology (OAST) and to present to you the proposed NASA Space Research and Technology and Energy Technology Programs and the associated budget requests for Fiscal Year 1983. I will be presenting only highlights of the program and accomplishments over the past year, as time is insufficient to cover the full range of activities.

SPACE RESEARCH AND TECHNOLOGY

It is my view that the Space Research and Technology (R&T) program should serve to maintain a technical disciplinary base of value not only to future NASA missions but for the military and commercial space efforts of this country as well. While the military and commercial segments perform applications research and development to implement technology in flight systems, it is NASA's unique role to explore, at the more fundamental level, the potential of emerging technologies. This responsibility dictates that the Space R&T program address a broad range of research critical to present and future space activities and to explore opportunities for advancing the most important technologies.

This breadth of activity is illustrated in Figure 1, which shows basic research in the disciplines of information processing, space power and electric propulsion, chemical propulsion, electronics and automation, materials and structures, and aerothermodynamics (or reentry aerodynamics). Systems research on critical space systems elements are also shown including information, spacecraft, and transportation systems. All work carried out by OAST complements and supports that done by the user-oriented offices of NASA. We are endeavoring to ensure that it also serves the commercial and military satellite communities as well.

The Space Research and Technology budget consists of three line elements which are illustrated in Figure 2. The budget element of Standards and Practices provides for the necessary agencywide support from our Office of the Chief Engineer. The budget request of $120 million for the Research and Technology Base and Systems Technology elements is 11 percent above the current FY 1982 estimate, allowing for a small amount of real growth. Our strategy for best utilizing these critical resources has been described in previous years' testimonies as giving the highest priority to the basic work carried on in the R&T Base. Over the past decade this prioritization has resulted in a lower level of effort in the Systems Technology element where the objective is to bring technology to the state where it can be considered suitable for application with moderate risk. It should be recognized, however, that the responsibility for this function must be assumed by the particular user program if not conducted by the Space R&T program.

As has been explained in previous testimony, NASA's organizational structure has been changed so that Field Centers report to the three program Associate Administrators. The new organization is depicted in Figure 3. The change was made to establish a clear distinction between line and staff functions at Headquarters and to improve the utilization of the centers. The Ames, Langley, and Lewis Research Centers now report to this office. Having the institutional responsibility for the Research Centers permits this Office to formulate and accept overall management responsibility for Construction and Facilities (CofF) and Research and Program Management (R&PM) budgets as well as managing the Aeronautics and Space R&D. The magnitude of the added institutional responsibility for OAST is illustrated in Figure 4. As shown on the right, total program resources supporting the Space Technology budget are $213 million. It should be emphasized that about 35 percent of these resources are provided to the Flight Centers, where a knowledge of system application needs and opportunities enhances the process of technology transfer. The spectrum of capabilities provided by both the Research and Flight Centers, shown in Figure 5, provides a balance in both the disciplinary sense as well as in the research and applications-oriented tasks.

I should like now to describe the programs for FY 1983, some accomplishments of this past year, and how the programs support our planning goals. The tasks are organized, as they have been in previous years, in the groupings of transportation, information, and spacecraft. The activities that support these categories are conducted within the disciplinary and systems related research areas identified in Figure 1. It is not intended to detail all activities, but rather to selectively portray the character and quality of the program. Of particular note this year are the many OAST space flight technology experiments that have been flown and the many others being readied for future flights.

Transportation Technology

The technology efforts in support of advanced transportation systems are directed to both the near-term objective of supporting potential evolutionary improvements to current NASA systems and the far-term objective of enabling the development of wholly new concepts. This technology activity extends across a broad multi-disciplinary base and spans the transportation needs of Earth-to-orbit, orbit-to-orbit, and planetary-transfer stages.

The two Space Transportation System (STS) flights brought to fruition a long period of planning and preparation for the OAST Orbiter Experiments (OEX) Program. The Space Shuttle provides an unprecedented opportunity to obtain flight research data on the performance characteristics of a space transportation vehicle. These data, unavailable from simulations in ground test facilities, are essential to a full understanding of Shuttle performance and to the validation of tools, both analytical and empirical, used to design the Shuttle. These OEX program results will enable improved future designs, cost-effective utilization of test facilities, and expansion of the Shuttle's operational capabilities. OEX flight experiments in support of research efforts in aerodynamics, thermal protection systems, and payload environment will continue through FY 1982 and FY 1983. Instrumentation will be added to expand the current capability for broadening the flight research data and analysis programs. Examples include: an on-board instrumentation pod to measure upper wing and fuselage heating; a high-resolution accelerometer package to characterize upper atmosphere aerodynamic performance; a mass spectrometer to further aid in upper atmosphere characterization and a low altitude instrument set to provide very high accuracy measurements of Orbiter velocity and attitude.

Measurements on the Shuttle Orbiter's Thermal Protection System (TPS) were obtained on both STS flights. Flight data were taken to verify the performance of TPS subsystem elements, namely the ceramic tiles, glass coating, and tile gap fillers. Initial analysis of STS-2 flight data indicates that the tile surface temperatures were significantly lower than the design criteria, except for those tiles which were coated to induce the catalytic behavior which was assumed in the design. These effects could not be confirmed in ground facilities. These findings will permit expanded cross-range capability in future Orbiter flights. Plans include a continuing effort to obtain accurate temperature maps of the Orbiter's surfaces.

Orbiter surface temperature data obtained in flight show the location of laminar to turbulent boundary layer transition. More extensive data will be obtained from future flights. Computational procedures and techniques have been developed for analyzing these data. Other on-board Orbiter experiments, including upper-atmospheric density measurements, Shuttle nose pressure measurements, and aerodynamic coefficients, will provide for comparative analysis of force and control characterization. These experiments provide research-quality data for evaluating and improving theoretical and ground-based experimental methods, leading to improved future vehicle designs.

The Dynamic, Acoustic, and Thermal Environment (DATE) program is another element of the Orbiter Experiments Program. DATE, a jointly funded NASA/Air Force program, will provide data on the dynamic, acoustic, and thermal environment in the payload bay. The recorded flight information will be used to derive realistic payload design and test criteria, to validate analytical predictive methods, and to develop techniques to assess combined vibration and acoustic load effects on payloads. Data from STS-1 and STS-2, while still being analyzed, indicate that the payload bay environment is more benign than assumed by current design criteria. This will help alleviate risks for spacecraft planning to use the Shuttle. Additional DATE measurement packages are planned for STS-3, 4, and 5.

With the valuable insights being gained from OEX data, it is timely and feasible to consider technology improvement programs that will offer significant improvements to the Shuttle. The current Space Transportation System is expected to be the nation's principal access to space through the turn of the century. With the introduction of improved technology, it will be possible to effect a more reliable, versatile, and cost-effective system. Options are being studied and technology is being generated for: extending life and performance of the Orbiter main engines; developing more durable thermal protection systems; streamlining mission planning and execution through automation; and more sophisticated design optimizations of such elements as the external tank thermal protection.

The ongoing research program on thermal protection systems is directed at materials of greater durability, longer life, and easier maintenance. A new, high strength, fibrous ceramic base material capable of higher temperature and with enhanced toughness has been characterized and fabricated into tiles for test and evaluation. Initial research studies on a new TPS concept using large sheet, carbon-carbon composite material offers the potential of significantly increased life. Research on durable systems, based on the inherently higher damage tolerance of metals, has shown considerable promise with the successful thermal exposure test of a multiwall titanium insulation material. Design iterations are underway. In FY 1983, continuing extensive thermal ground tests will aid in evaluating these and other concepts.

The Earth-to-orbit propulsion technology program is aimed at significant extensions in life and performance of the Orbiter main engines. Initial work is leading to a better understanding of engine operating environments and assessing the effects on engine component life. Analytical models are being developed to describe: the dynamics of turbopump rotating machinery; behavior of high speed bearings in cryogenic systems; flow distribution and dynamics of hot gases in the injectors; and structural dynamics of the engine. This knowledge will be employed to develop life prediction techniques and life extension programs. New materials, fabrication processes, and diagnostic techniques are being explored including: powder metallurgy; ceramic coatings; crack detection techniques; and sensing techniques for incipient failure detection.

The payload capability of possible future reusable transfer vehicles to geosynchronous orbit could be substantially increased by using an aerodynamic braking technique to facilitate return to low-Earth orbit. Preliminary assessments indicate that orbital transfer vehicle payloads might be doubled. In FY 1983, continued emphasis will be placed on: predicting vehicle flow fields and performance; improving ground-based experimental techniques; and developing a ground and flight test data base for aerodynamic maneuvering vehicle design.

Future systems will face requirements ranging from high acceleration roundtrip transfers for resupply, to very low acceleration one-way transfers of large, flexible structures. A variable thrust propulsion technology program is directed towards providing high performance over a broad throttling range for orbital transfer vehicles operating between low-Earth orbit and geosynchronous orbit. With current engines, significant performance loss occurs at low thrust levels. FY 1983 technology plans include the development of key technologies for efficient, variable flow turbopumps and for stable, high pressure, high performance combustors.

The transportation technology programs, represented by these elements, are seen to rely heavily on flight and ground experiments and are expected to help in the successful evolution of an improved national space transportation system.

Information Technology

The information systems research and technology program provides advanced sensor, data, and communications technology options that will enable and enhance systems for Earth resources, environmental observations, and space science missions, as well as provide technology for the Agency's thrust toward a permanent manned presence in space. These technology options focus on efficient and timely acquisition, processing, reduction, and distribution of space-acquired information. Extensive experimental data, both flight and laboratory-derived, is being acquired in this technology area and applied, jointly with our user flight offices, to program applications.

The objective of the Feature Identification and Location Experiment (FILE), flown on STS-2, is to develop and evaluate an instrument capable of spectrally sensing and quantitatively classifying the Earth's surface into identified picture elements in each of four classes: vegetation; bare Earth; water; and cloud cover, snow, and ice. This instrument classifies scenes and counts the number of picture elements, pixels, in the scene for each class. It then assigns the scene to the class whose pixels predominate. The scene is also recorded photographically including the intensity of each of the two band images for each pixel in the scene. Real-time image classification was achieved for the first time on STS-2. A reflight of this experiment is planned on OSTA-3 to gather statistical data at improved sun angles. A magnetic bubble recorder, as backup to the tape recorder, may also be incorporated.

Improved sensing techniques for measuring rare gas elements in Earth and planetary atmospheres would be an important advance. A laser heterodyne spectrometer, using tunable diode lasers as local oscillators, is being constructed for an aircraft flight verification of the concept. Operation requires that precise wavelength identification be made by comparing the measurement data with the signature of a known gas contained in a cell within the instrument. Very high resolution and the capability of simultaneously measuring two atmospheric trace species are required. During FY 1981, a laboratory model was fabricated and tested including the cooler and star tracker subsystems. Measured performance was favorable and a flight prototype will be assembled, tested, and calibrated during FY 1982. Flight readiness is targeted for late 1982 following shipment to Ames Research Center and installation aboard the CV-990 "Flight Laboratory."

New means are required for reducing the increasingly large quantities of data acquired in space. A real-time signal processor which exploits the phenomenon of light scattering in solids by acoustic waves has been built. This acousto-optic processor has six times the frequency resolution of ordinary filter banks at a tenth of the weight and power consumption. It will be experimentally tested by ground-based processing of signals acquired from terrestrial, solar system and galactic observations. The ultimate advantage of this concept is that it can be constructed on a single, solid-state chip to eventually enable real-time, on-board signal processing with dramatically small power consumption, negligible weight and size. During the next fiscal year, this chip design will undergo experimental development.

Another step in the efficient management of space-acquired data relates to format improvement. Advanced data system studies have concluded that space-acquired data in "packet" form should be an integral part of long-term NASA data system architectures. Standardizing packet data accomplishes: reduced costs by automation; elimination of unique hardware and software; simplified quality control; deterministic data accountability; autonomous instrument formatting; and consistent interfacing throughout instrument life. Packet guidelines were approved and distributed to NASA program offices and a packet transmission was emulated via NASCOM from JPL to GSFC. During this fiscal year, ground software will be completed followed by a demonstration of prototype flight hardware in FY 1983. The Office of Tracking and Data Systems will be introducing the technique, as described in their testimony, in the Space Telescope Program. The International Solar Polar Mission (ISPM) has chosen to apply the packet techniques and nine other programs are assessing its use.

Space communications depend heavily on the use of the Traveling Wave Tube (TWT), but the technology for its reproducible fabrication has been beset with production and cost problems. The "tunneladder" slow-wave circuit is a potentially inexpensive alternative to the conventional coupled-cavity, high power TWT. The tunneladder circuit consists of one or more ladder-like arrays of conductors arranged to form a waveguide. Its improvement potential is derived from the fact that the ladder and the outer shell are produced separately, permitting a variety of fabrication techniques to be employed. Upon assembling a tunneladder circuit tube, only a few relatively large parts need to be brazed, in sharp contrast to a coupled-cavity TWT which consists of hundreds of machined parts. A program is underway to develop a low-cost, 29 GHz TWT for use in terrestrial transmitters. This technology base could also be applied to communication spacecraft systems in the 30/20 GHz range. The first ladder structures have been fabricated and the first 29 GHz tube is expected to be built this fall. Plans for FY 1983 call for the fabrication and test demonstration of a 40 GHz space-based tube.

It is, I hope, evident that the demands of the next decade for exponentially increasing quantities of data, and more importantly, useful information are being addressed by the Information Technology program.

Spacecraft Technology

Spacecraft technology provides the focus for the development of future large space systems and Earth orbiting and planetary spacecraft. The foundation for these developments is the disciplinary activities in materials, structures, power, propulsion, controls and automation. They also depend on basic research in physics and chemistry to develop fundamental understanding of behavior and predictive methods for component performance. Mission and systems analyses identify technology and research options and opportunities. Validation of systems performance is accomplished through integrated systems tests, both ground and space-based, and such will dominate our report this year.

The materials and structures research program includes the development of new concepts applicable to possible future erectable and deployable large space systems, supported by analysis, design, and experimental validation techniques. Truss structures are being emphasized because they provide high stiffness as well as surface accuracy. A Langley Research Center concept for space assembly of structures, too large or complex to fold and deploy, was recently evaluated in the Neutral Buoyancy Facility at the Marshall Space Flight Center. Pressure-suited astronauts assembled a 36-element truss using five-meter long nestable struts made of graphite epoxy. Total assembly time of 35 minutes permits a prediction of only 45 seconds per member for the space environment. Plans for FY 1983 are to generate structural designs, deployment schemes, and packaging techniques that could be used to test a possible future 200-meter sized planar structure that could be carried into orbit and automatically deployed.

Another element of the large space system technology program deals with large antennas in which proof of concept will be demonstrated in a ground test. By deployment of four gores of a 50-meter diameter antenna reflector, we believe we can verify the mechanism design, understand mesh deployment, and evaluate the mesh surface precision. The construction of test hardware and of the test set-up is underway. Testing will begin in FY 1982 and continue into FY 1983. There are two competing concepts, "wrap rib" and "hoop column," which will be evaluated in the test program.

The construction, repair, and maintenance of space systems require a vigorous program of developments in teleoperators and robotics. The immediate program focus is the development of supervisory robotics control with sensory feedback. Fundamental research on stereo computer vision for real-time robot control is progressing toward a 1986 major capability demonstration, and approaches for supervisory control of complex robot tasks are being developed. During the past year, a proof-of-concept demonstration in stereo tracking was accomplished by use of an image feature extractor which enables visual tracking at 15 frames a second.

The Induced Environment Contamination Monitor program was initiated in response to user concern about STS contamination to optics, solar cells, and heat transfer surfaces. The monitor is a composite of ten instruments that measure the STS environment during all phases of Shuttle operation from preflight through postflight. Installed in the Orbiter payload bay, the equipment was successfully flown on the STS-2 mission. The results are encouraging with preliminary indications that contamination levels are within the requirement goals. The monitor flown on STS-2 has been refurbished and is currently installed in the STS-3 Orbiter bay awaiting flight. STS-3 and STS-4 missions are planned for longer duration. In FY 1983, the instrument will also be carried on STS-10, the first Spacelab mission.

Studies of possible future large space systems such as the Applications Platform, the Space Operations Center, and space stations continue to identify the need for improved energy storage. The fuel cell/electrolyzer offers potential weights one-half that of Ni-Cd storage batteries. This concept integrates two advanced technologies, fuel cells and water electrolysis, into an efficient energy storage system. A test model will be received during FY 1982 and an alternative design concept test model in FY 1983. After comparative evaluations, engineering development will be undertaken with technology readiness expected by 1986.

Both civil and military forecasts show possible future space missions could require large amounts of power at high power densities, which are radiation-resistant and operate for long periods of time. DOE has been researching a space nuclear reactor with NASA focusing its efforts on critical technologies for the conversion of reactor thermal energy to electrical power. Research in thermoelectrics, during the past year, has resulted in identifying improved high temperature materials which have potentially high efficiency levels. Plans also include an effort to develop technology to improve heat conduction from the reactor core to the thermoelectric elements by using high temperature heat pipes. These critical technology developments and the DOE work on the reactor core are essential to providing a basis for future consideration of this power system option.

Highly autonomous spacecraft offer the possibility for all mission classes to potentially effect large cost reductions in spacecraft operations and to reduce dependence on ground control. Spacecraft functions and operational timelines, which can be automated, have been identified and a plan generated to proceed with technology development. Considerable commonality exists with the

Air Force needs for spacecraft autonomy, and joint activities are being vigorously explored. During the last Voyager encounter, an autonomous optical navigation experiment was successfully accomplished. In the planned period we will initiate technology development for autonomous thermal, attitude control, and power subsystems. By FY 1984, a ground test verification program will be initiated for demonstrating the integration of computers, sensors, actuators, and algorithms into autonomous subsystems. An all-up system ground demonstration could be available by 1986.

A flight test article of the Ion Auxiliary Propulsion System is in final systems test. It will be flown to verify, in space, the functional operation and life of a one millipound thruster, and to obtain insitu measurements of efflux particles and electric fields. This thruster system is, for example, suitable for north-south stationkeeping of geosynchronous military and civilian communications satellites. NASA is scheduled to deliver the flight hardware to the Air Force this spring for integration into the Teal Ruby Spacecraft, scheduled for launch in 1983 under an interagency memorandum of agreement.

Mission/technology references, in the form of space system technology models, provide an ideal basis for joint planning and analysis efforts, and ultimately more effective NASA/Air Force Interdependency. In the latest interdependency meeting held this past January, joint expert teams assessed mutual technology interests derived from the NASA and military models. This led to a prioritized list of potential joint programs. While formal memoranda of agreement exist or will be generated for exchange of data in some 25 activities, efforts are proceeding to select a half-dozen for intensive, jointly planned and committed programs.

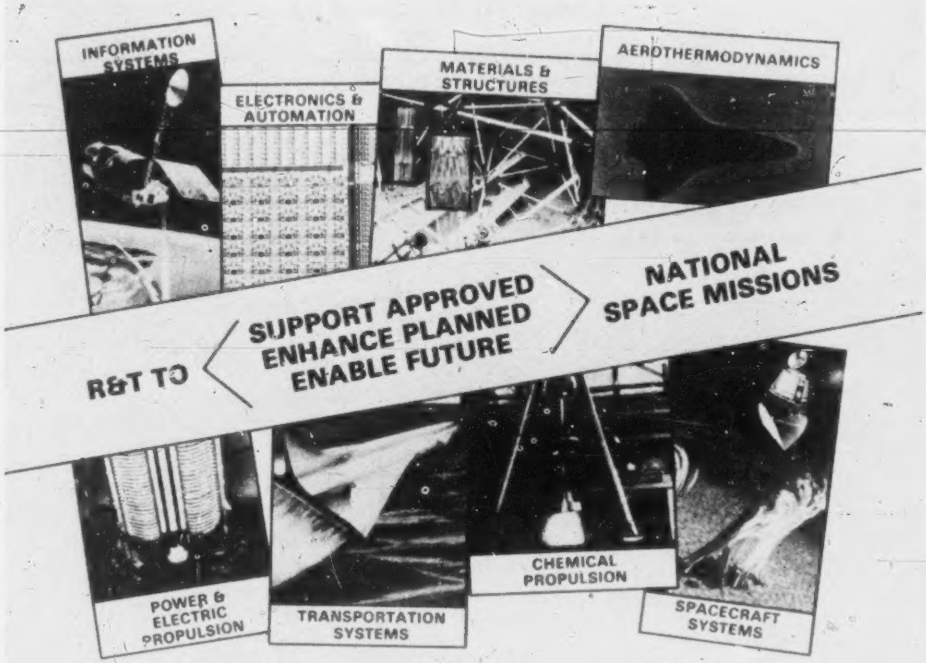
The process of interactive technology planning requires extensive activity both internal and external to NASA and yields: a broad knowledge base of capabilities and forecasts; a means for accomplishing technical and management peer review of programs; a nationally coordinated program that precludes voids and overlaps between NASA, industry, academia, and other government agencies; and contributes significantly to the effective transfer of technology from developer to user. The previous discussion of NASA/Air Force interdependency is illustrative of the benefits that can accrue from these exchanges. The product of this interactive process is the assurance that the NASA Space Research and Technology Program serves as a national resource filling not only NASA's future mission needs but those of the military and commercial sectors.

ENERGY TECHNOLOGY

And now, Mr. Chairman, I would like to close by saying a few words about our activities that support national energy programs.

Although in past years there has been NASA-funded energy work, we are not requesting funds for this purpose and our energy involvement now consists solely of supporting DOE and other agencies, on a reimbursable basis, by conducting energy research and technology. These efforts have been underway for approximately ten years and progress has been made in many important technology areas. Four of these programs are illustrated in Figure 6, large wind turbine development, photovoltaic systems, fuel cells, and advanced heat engines, with the example shown being the automotive gas turbine. Industrial involvement in these programs has been an important key to the accomplishments that have been made. Large wind turbine technology has progressed to the point that utilities are considering them for new generation capacity. Photovoltaic systems have been deployed in this country and abroad to provide electric power for specialized applications. Although the cost is still many times that of more conventional means of power generation, the cost of these systems and, most importantly the cost of solar cells themselves, has been coming down steadily. With DOE and the Gas Research Institute (GRI), we have begun the purchase of 45 fuel cell units that will be deployed throughout the country to provide operating experience with these efficient, clean, electric power-producing systems. The automotive gas turbine holds the promise of high efficiency and a technological jump ahead for our auto industry. These are just a few examples of the technology areas we have been supporting over the past years.

With continuing reductions in civil service manpower, these energy related efforts detract somewhat from our ability to carry out our responsibilities for aerospace research. We have attempted to minimize this impact by choosing areas of activity which produce technology advances of potential benefit to aeronautics and space. However, as we look ahead, we find it will be necessary for NASA to phase out its civil service manpower support to energy by the end of FY 1983 in order to more appropriately devote the available manpower to our traditional programs. The Jet Propulsion Laboratory will continue to provide support to energy areas where they have the capabilities required to successfully accomplish program goals. I want to assure this Committee that we will structure this transition in coordination with the sponsoring agencies such that the investments that have been made will be protected and an efficient transition to new management will be carried out where appropriate.


INFORMATION SYSTEMS
ELECTRONICS & AUTOMATION
MATERIALS & STRUCTURES
AERDTHERMODYNAMICS
R&T TO
SUPPORT APPROVED
ENHANCE PLANNED
ENABLE FUTURE
NATIONAL SPACE MISSIONS
POWER & ELECTRIC PROPULSION
TRANSPORTATION SYSTEMS
CHEMICAL PROPULSION
SPACECRAFT SYSTEMS

NASA OAST

Figure 1

SPACE RESEARCH & TECHNOLOGY

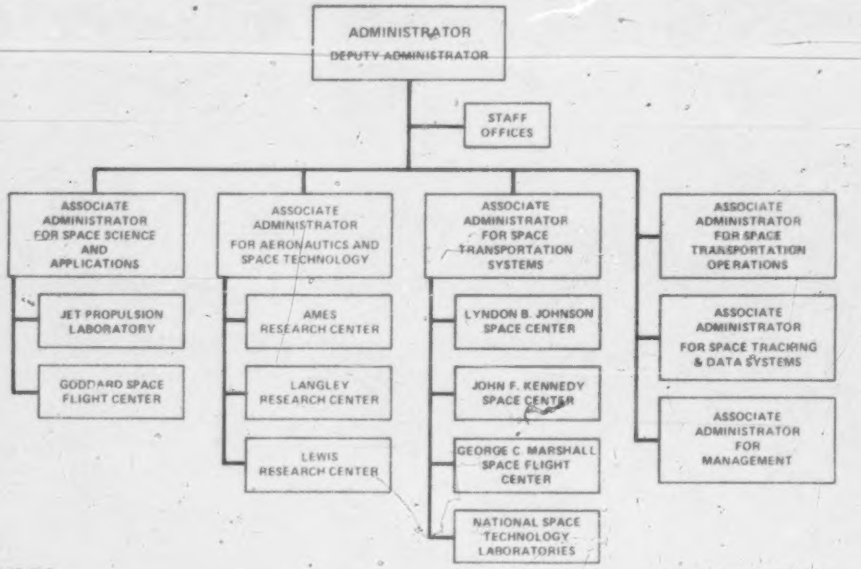
R&D BUDGET
($M)

	FY 1981	FY 1982 BUDGET ESTIMATE	FY 1982 CURRENT ESTIMATE	FY 1983
R&T BASE	100.4	115.3	105.2	115.6
SYSTEMS TECHNOLOGY	8.2	7.0	2.8	4.4
STANDARDS & PRACTICES	2.1	3.0	3.0	3.0
TOTAL R&D	110.7	125.3	111.0	123.0

NASA OAST

Figure 2

NASA ORGANIZATION


ADMINISTRATOR
DEPUTY ADMINISTRATOR
STAFF OFFICES
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
AMES RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEMS
LYNDON B. JOHNSON SPACE CENTER
JOHN F. KENNEDY SPACE CENTER
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION OPERATIONS
ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING & DATA SYSTEMS
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

NASA OAST NASA HQ 82R 512(3) 1 18 82

Figure 3

OAST INSTITUTIONAL AND PROGRAM RESOURCES

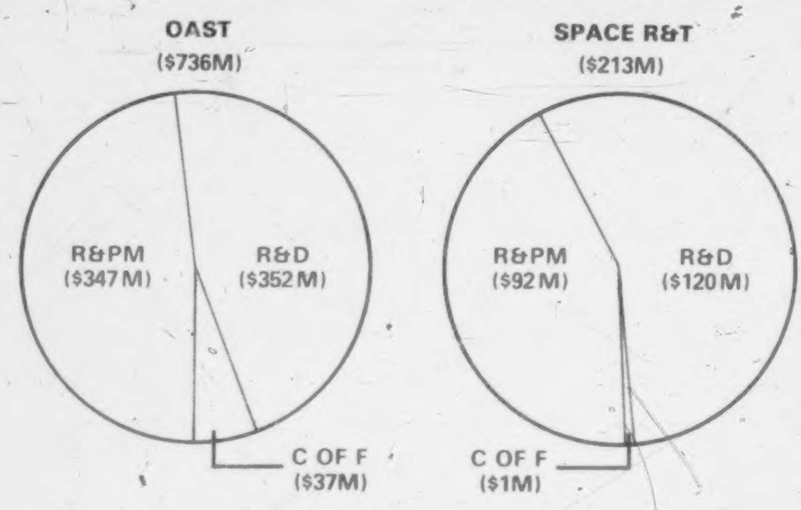


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Figure 4

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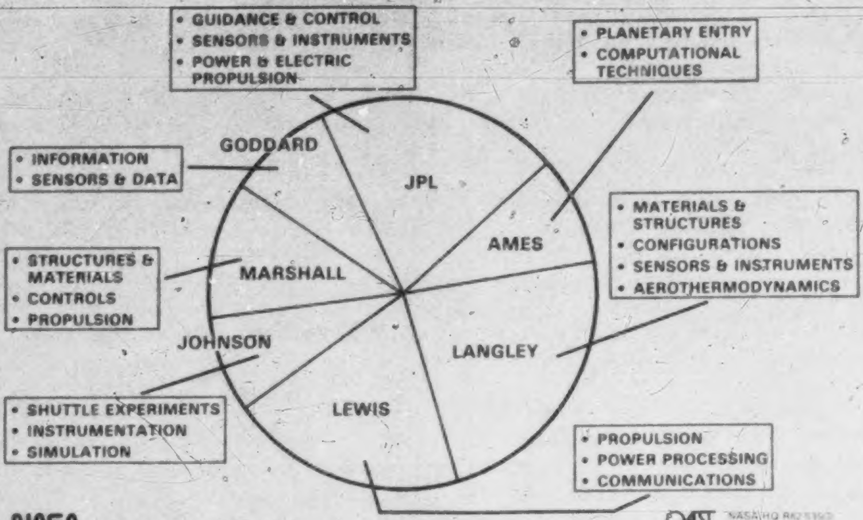
FUNDING DISTRIBUTION & ROLES

(R&D BUDGET – $120M)



- GUIDANCE & CONTROL
- SENSORS & INSTRUMENTS
- POWER & ELECTRIC PROPULSION

- PLANETARY ENTRY
- COMPUTATIONAL TECHNIQUES

- INFORMATION
- SENSORS & DATA

- MATERIALS & STRUCTURES
- CONFIGURATIONS
- SENSORS & INSTRUMENTS
- AEROTHERMODYNAMICS

- STRUCTURES & MATERIALS
- CONTROLS
- PROPULSION

- SHUTTLE EXPERIMENTS
- INSTRUMENTATION
- SIMULATION

- PROPULSION
- POWER PROCESSING
- COMMUNICATIONS

NASA

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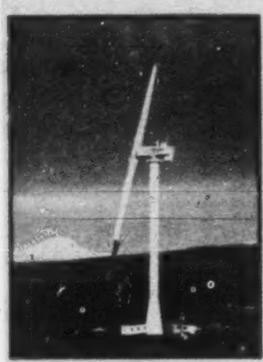
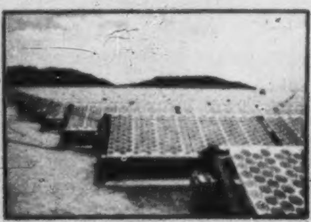
Figure 5

NASA ENERGY TECHNOLOGY

MAJOR REIMBURSABLE PROGRAMS



EXPERIMENTAL 2500 KW
WIND TURBINE



60 KW PHOTOVOLTAIC SYSTEM

AUTOMOTIVE GAS TURBINE
GENERAL MOTORS CONCEPT

PHOSPHORIC ACID
FUEL CELL
40 KW VERIFICATION UNIT

NASA

OAST NASA HQ RE82-534(3)
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Figure 6

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[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question: What is the extent of your nuclear electric propulsion technology development? Do you foresee any direct application of this technology in the near term?

Answer: Nuclear electric propulsion (NEP) has long been recognized as an enabling technology for the intensive study of the outer planets. The principal components of a NEP system are the reactor, the thermal-to-electric conversion system and the electric thrusters. The technologies are being developed separately, since applications other than NEP are also considered.

Nuclear Reactor and Energy Conversion

There is a small tri-agency (NASA/DARPA/DOE) effort underway to develop critical technologies which may enable the development of a nuclear reactor power system by the mid 1990's. There are several military applications in addition to potential civil uses such as earth orbital platforms, planetary and lunar bases and planetary orbital research stations. The tri-agency program, named SP-100, is jointly supported by NASA, DARPA, and DOE.

The baseline design consists of a fast, UO_2 fueled, heat pipe cooled reactor. The technologies are being developed primarily at the Los Alamos National Laboratory and are concentrated on the heat pipes, materials compatibilities, and fuel swelling problems. The thermal-to-electric energy conversion work consists largely of advanced materials research, which is concentrated at the Jet Propulsion Laboratory.

Electric Propulsion

There has been a NASA research and technology effort in electric propulsion systems since the establishment of NASA. The electrostatic electron bombardment thruster has been developed to a high level of technology readiness. In 1981, it was declared ready for the initiation of the phase C/D development of a photovoltaic powered planetary stage. This system produces 30 millipounds of thrust per engine at a specific impulse of 3000 seconds. Each engine uses 3 kilowatts of electrical power. Ion thrusters have considerable growth potential to meet the needs of a nuclear electric propulsion system. NASA currently has an active technology program to extend the existing capability. The program goals include doubling the thrust to power ratio of the thruster from 10 mlbs/kW to 20 mbls/kW, characterizing the performance over the 1400-5000 second specific impulse range, and decreasing the specific mass from 35 kg/kW to 15 kg/kW. The electric propulsion technology program is funded at three million dollars in FY 1983 and is supported by approximately sixty engineers and support staff primarily at the Lewis Research Center.

Applications

Nuclear electric propulsion is not planned for the near term; studies have shown, however, that NEP is enabling technology for very difficult outer planet missions.

Nuclear reactor power subsystems are likely to be flown in the mid 1990's, with the first application likely in military missions. Photovoltaic electric propulsion for station keeping is being used and more advanced applications are expected.

The most likely first application of ion propulsion is north-south station keeping of geosynchronous communications satellites. In the somewhat longer term, electric propulsion could be used for space station drag cancellation, orbit transfer, and inclination change of large payloads in earth orbit.

Question: What is the status of research on fiber optics technology for use in space applications?

Answer: A major research goal of increasing the upper limit on the information bandwidth of optical fibers is dependent on the pulse width of the optical signal. Research in the mechanisms of minimizing the pulse width has enabled 30 picosecond pulses which would amount to pulse-coded modulated data streams of a gigabit per second.

An experimental fiber optical link 500 meters long consisting of a laser source, the laser driver circuit, multiplexer, and receiver was built and a data rate around a gigabit per second was measured. For frequencies in excess of this, the rates are limited by pulse ringing and jitter and frequency chirping. Current research is devoted to the understanding of the physical mechanisms responsible for this. NASA, in conjuction with the Air Force, will fly an experimental fiber optics data communications package at the lower frequencies for evaluation on the Long Duration Exposure Facility (LDEF) planned for a future Shuttle mission.

Question: Would you please describe in more detail your proposed work in 1983 on robotics and machine intelligence?

Answer: At the present time, OAST's Automation R&T program has two specific objectives: (1) Machine Intelligence; and (2) Teleoperators and Robotics.

Machine Intelligence

Research is being initiated in automated decision-making, problem solving, expert systems, machine perception and eventually machine learning to provide a technology base to increase the degree of autonomy of spacecraft, space station, and even ground mission type operations supporting space flight. The research thrust is drawing from the important new theoretical and experimental developments in the university artificial intelligence community. In FY 1983, the automated experiment sequencing and planning algorithms for spacecraft will be completed. The focus will shift to autonomous operations for space station starting with research on applications of expert systems theory to the power system. An interdependent program is being developed with the Air Force Space Division for autonomous spacecraft technology.

Teleoperators and Robotics

Research is being done in control logic, manipulators, sensing and actuation technology needed for the space environment and application areas such as assembly in space, satellite retrieval and servicing, remote experimentation, and in the long-term, remote exploration and space manufacturing. The early focus of the program is on teleoperator experiments and theory, and evolving towards robotics as the state of technology advances. In FY 1983, a hierarchical control methodology to determine appropriate levels of direct control by the human operator, supervisory control, and automatic control for teleoperators should be completed. Basic control logic is being studied at Stanford University to allow precise control of extremely lightweight, very flexible arms for robots. The third major thrust is the study of feature extraction concepts for vision systems using relatively high intelligence levels.

Question: What do you see will be the effect of the elimination of the space systems studies and information systems technology line items in 1983?

Answer: The Space Systems Studies line item has been deleted so that there is no longer a sustaining level of effort budget element to assess technology planning against perceived future program needs. Clearly, needs will arise to conduct such studies on specific issues; the mechanism for funding will be to utilize the R&T Base budget from the most appropriate source(s) at the time such need develops. The Space Systems Technology Model will serve as a consolidating and efficient focus for filling this planning need.

Despite elimination of the Information Systems line item, OAST maintains within the R&T Base a viable core communciations research and technology program in both 30/20 and narrowband to provide options for increased satellite communciations capabilities. The OAST program focus is on high-risk technologies for a broad spectrum of applications in the early 1990's. The activities encompassed by this research and technology program provide reduced technical risk to implement complete communication systems in new bands and improve utilization of existing bands. Major program activities include systems analysis and synthesis, microwave electron beam technology, microwave amplifiers and receivers, multibeam antennas, and solid-state materials and components.

Question: How has support for technology development changed over the past decade in terms of the NASA total budget? How does the percentage that NASA spends for technology development compare to what major U.S. corporations spend to develop new products? Is the current budget sufficient to maintain a strong technology base and thereby retain its leadership in space?

Answer: The NASA investment in space technology has been declining for many years. Expressed in FY 1983 dollars, the Space R&T budget in FY 1970 was in excess of $350 million while in the proposed FY 1983 budget, it is $120 million. This is a drop from 3.9 percent to 2.2 percent of the Agency's R&D budget. The FY 1970 figure has been reduced to exclude any budget assigned for nuclear research being conducted at that time so it is on a valid basis of comparison. The NASA manpower assigned to Space R&T has declined from about 3,300 in FY 1970 to about 1,383 in FY 1982, representing a percentage decrease from 15.1 percent to 8.4 percent of the total Agency's direct position.

It is extremely difficult to extract comparable data for industry because of the highly judgmental and sensitive nature of what constitutes research; but most progressive organizations that have successfully exploited research contend that the 5 percent level constitutes an appropriate basis. With much of the aerospace industry expanding their military sales, they have been able to increase their allowable overhead contribution to Independent Research and Development.

The budget erosion since 1970 has resulted in a technology base which focuses primarily on institutional support and on only the highest priority technology needs. The current request, however, represents what we consider as a judicious application of the scarce Federal resources.

Question: Do you feel that the intensity of interaction between NASA and the Air Force is sufficient for the present in the area of technology planning, and is this effort sufficiently supported by the Air Force from NASA's point of view? In your view, do we now have a nationally coordinated program for space technology?

Answer: NASA and the Air Force presently have excellent interaction in the area of technology planning through a joint agency working committee. Principal investigators from both agencies maintain contact for purposes of information exchange, planning coordination, and where feasible and desirable, possible future joint efforts. In the latest interdependency meeting held this past January, joint expert teams identified numerous programs of mutual interest from 31 broad technology areas which merited specific review. Of these, 6 programs have been subsequently selected for intensive joint planning of committed resources and technology goals. Several programs have already developed into joint activities which are formally documented by Memoranda of Agreement (MOA).

While there is sufficient technology coordination with the DOD and especially the Air Force, interaction with the current and potential civil users of space in the technology discipline areas is less intensive.

Question: Would you please provide some examples of areas in which NASA and the Air Force are considering proceeding with joint technology programs?

Answer: The following broad technology areas have been identified as being of mutual interest between NASA and the Air Force. No priorities should be assumed from the following list.

1. Aeromaneuvering
2. Automated Spacecraft Maintenance
3. High Power Orbital Systems (MOA in process)
4. Chemical Propulsion Research
5. Composite Material Antennas

6. Computer Mediated Teleconferencing
7. Infrared Detectors and Sensors
8. End-to-End Data Systems
9. Dynamic Control of Large Space Structures
10. Space Environmental Effects (MOA)
11. Platform Systems
12. Fiber Optics
13. Solar Cells (MOA in process)
14. Electric Propulsion (MOA)
15. Large Optics
16. Laser Fiber Optics Gyro
17. Lithium, Nickel-Hydrogen, and Nickel-Cadium Batteries
18. Near/Submillimeter Wave Technology
19. Star-tracker for Autonomous Navigation and Attitude Reference
20. Onboard Data Processing (MOA in process)
21. Radiation-Hardened Electronics
22. Satellite Communications at X-band and at 30/20 GHz (MOA)
23. Dynamic, Acoustic, and Thermal Environment for Shuttle Payloads
24. Solid-State Mass Memory Devices (MOA)
25. Particulate Contamination in Space Environment
26. Space Charging in Orbital Plasma Environment (MOA)
27. High Power Spacecraft Environmental Interactions (MOA)
28. Traveling Wave Tube Failure Analysis (MOA)
29. Computer-Aided Design, Manufacturing, and Test
30. Tele-operated Maneuvering for Space-based Operations
31. Deployable Large Antennas

There are two programs receiving joint funding from NASA and the Air Force under single, unified contracts: "Archival Mass Memory for Computers" under item 24, and "30/20 GHz Traveling Wave Tubes" under item 22. Under item 28, a "Traveling Wave Tube Technology Improvements" program provides for Air Force procurement of prototype devices and subsequent NASA testing to be coordinated through the MOA process. NASA testing is conducted by the Lewis Research Center for the Air Force on a continuing basis. The Ion Auxiliary Propulsion System, from item 14, has extensive interdependency at the project level and is scheduled for testing abroad an Air Force P80-1 spacecraft. Plasma interaction studies are being conducted under both items 26 and 27, with NASA and DOD each performing separate, coordinated segments of the program. Items 3, 10, 13, 14 and 20 have MOA's which formally establish coordination terms of reference and the parameters to be addressed.

Senator SCHMITT. Our next witness is Robert E. Smylie, Associate Administrator of Space Tracking and Data Systems.

STATEMENT OF ROBERT E. SMYLIE, ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING AND DATA SYSTEMS, NASA

Mr. SMYLIE. Thank you for the kind words for the support activities that we provide to the agency.

Senator SCHMITT. I never let you forget losing the uplink. You weren't there. That wasn't on your watch.

Mr. SMYLIE. I would like to point out at least a couple of things that have been major accomplishments of the network in the past year. One is the outstanding support of the network for the first two manned Shuttle flights, and to note that we are ready, prepared, and certified for the support of STS-3 to be launched next week. Also, the DSN provided outstanding support for the Voyager 2 mission to Saturn, returning all of the images that were planned to be returned from that mission. The tracking and data relay satellite system [TDRSS] has made substantial progress within the past year.

There have been no changes in my organization since the last time I was here, but we have had a number of key personnel assignments which I would like to note for the subcommittee. Mr. Charles Taylor, who was for many years Director of our Network Systems Division, has retired and will be leaving us in April. We are sorry to lose him. He has been a substantial contributor over many years and is very difficult to replace. We have been fortunate in attracting Mr. Bill Wood, formerly the Deputy Director of Networks at Goddard and more recently our representative in Australia, to replace Mr. Taylor in that position. Mr. Wood is here today.

Since I was here last, our Manager of the Deep Space Network program left us to rejoin JPL. We have been fortunate to get Mr. Charles Force, who was formerly Chief of the Networks Operation Division at Goddard and more recently in private industry for the past 2 years, to rejoin the Government as Manager of the DSN program.

Lastly, to replace Mr. Wood in Australia, astronaut Joe Kerwin has agreed to accept a 2-year assignment to represent our office and the agency. I am sure he will do an outstanding job down there.

I have a prepared statement to submit for the record which I will summarize at this time. The program that we manage provides the vital tracking, command, telemetry, and data acquisition support to meet the requirements for NASA Earth-orbital science and applications missions, planetary missions, sounding rockets, research aircraft, and all phases of the Space Shuttle program. We provide this support through two worldwide tracking networks. A global communications system links the tracking sites, the control centers, and the data processing facilities providing real time data processing for mission control, orbit and attitude determination, as well as routine processing of telemetry data.

For fiscal year 1983 we are requesting a total of $508.9 million to provide for the continuation of this support to the flight projects. The support will continue for the ongoing missions as well as preparations for the Space Telescope, Galileo, Spacelab, the Uranus encounter of Voyager 2, and the tracking and data relay satellite. A major effort will continue also to consolidate three space tracking and data network stations with those of the Deep Space Network under the management of JPL with this consolidation to occur in the 1984–85 time period.

In the operations portion of the requested budget, $338.2 million is requested for flight support operations which represent the major portion of our fiscal year 1983 request. This amount represents a continuing reevaluation of support requirements, and resulted in program reductions which included the closure of the Quito, Ecuador, and Tula Peak, N. Mex., tracking facilities, the closure of the Deep Space Network 26-meter antenna subnetwork, and staffing and shift reductions at a number of our tracking stations.

The significant increases in this operations budget are for escalation and the funding of activities in preparation for the initiation of the tracking and data relay satellite services in fiscal year 1983. We do operate a labor intensive organization and inflation due to personnel compensation does have an impact on our funding requirements. Also energy costs continue to increase, or at least have to date, in spite of decreases in the consumption through conservation and station closures.

There are a number of operational activities associated with preparation for tracking and data relay satellite services in 1983. These include the related ground systems that are crucial to the operation of the total system such as completion of the network control center software and staffing buildups to operate the ground systems. We are requesting $96 million for systems implementation with funds required to sustain the existing ground support facilities and systems to support a wide variety of missions and to provide for new capabilities to meet the special requirements of upcoming individual flight projects. Within this budget, we are continuing a phased replacement of major computer systems at the Goddard Space Flight Center, upgrading the communications system also at Goddard, and continuing a study of future tracking and data relay satellite configurations and undertaking the development of onboard systems to work with TDRSS.

Funding is required to continue implementation of new capabilities for upcoming missions such as the Space Telescope, Galileo, Spacelab, and the Uranus encounter of Voyager 2. Also within this implementation budget is included the effort underway to consolidate and reconfigure the space tracking and data network stations with the Deep Space Network.

We are requesting $13.4 million for advanced systems. With rapid changes taking place in the state of the art of telecommunications and computer technology, these areas need to be continually assessed and technology applied to meet the advances required for future missions support. Such technology which can be applied include improved navigation accuracies for planetary spacecraft, use of higher frequencies and digital processing of very high telemetry data rates. It is through such efforts that a crucial technology base is developed and made available for future support capabilities.

Our fiscal year 1983 request includes $61.3 million for payment of the first initiation of tracking and data relay satellite services. These services are being procured through a long-term service contract from the Space Communications Co. The funds requested are to initiate repayment of the construction loan and to make operations payments to the contractor for the services provided. Our current estimate of the NASA cost for the 10-year service contract, including development, operations and interest cost, is $2.3 billion based on initiation of loan repayments in July 1983.

The TDRSS will consist of an operational constellation of four spacecraft in geosynchronous orbit—a ground terminal located at White Sands, N. Mex., and scheduling of communication facilities at Goddard. During fiscal year 1983, we plan to conduct the first two launches and establish the initial operating capability on the system.

Since my last appearance, a number of significant program milestones have been accomplished. The first spacecraft has successfully completed its environmental test program. At this time last year, I shared with you some technical concerns involving solar arrays and traveling wave tube amplifiers [TWTA]. Both of these major elements are now performing well. The solar array design has been modified to relieve thermal stress and final testing is underway. The TWTA manufacturing processes have been altered and upgraded by the contractors, resulting in production of better quality tubes which we believe will have the high reliability necessary for an extended service period.

The ground terminal is progressing well. At this time last year we were considering substituting more capable computers to forestall operational problems and to incorporate security provisions in that ground terminal. Last summer that substitution was made and the data processing equipment has been installed and integrated. Software debugging and service level testing are continuing pretty much on schedule, and we have begun data flow with compatibility testing between the NASA systems and the ground terminal. We expect to complete our interface testing by September in preparation for a launch by January of next year. Several NASA systems are integral to the delivery of user-support services via the tracking and data relay satellite service. Among the key elements are the NASA ground terminal at White Sands that interfaces with the contractor facilities there, the network control center at the Goddard Space Flight Center, and the associated computing and interconnecting communication systems. These systems are also in various stages of delivery, installation, and test, and are for the most part progressing well.

Our major problem within the past year has been the development of the hardware and software for the network control center at Goddard. We have had difficulty in bringing the software to the state of readiness needed for the program. It has been reevaluated over the past year, and we have modified the program in ways that we believe give high probability of a successful completion to provide the required mission support on schedule. In order to back up that activity, we have also initiated a fallback system of much less complexity at the Goddard Space Flight Center as an alternate interface to the White Sands station.

This year will be a year of intense activity in preparation for the launch of the first spacecraft. As you know, TDRSS will be the first launch of the inertial upper stage [IUS] from the Shuttle. Our mission preparation and planning will be dealing with the first launch of Orbiter 099, the first IUS and the first TDRSS spacecraft, making it a somewhat complex mission. It requires a great deal of coordination and detailed planning, as the Shuttle will be controlled from the Johnson Space Center, the IUS from the satellite control facility in Sunnyvale, Calif., and the TDRSS from White Sands.

We have the management team in place to carry out that mission. The planning is well underway and we think well under control.

I think I will stop there to answer any questions you may have.

Senator SCHMITT. Thank you. Your testimony indicates the closedown of the Tula Peak operation is in large part in order to bring up the Dakar system in support of STS-4. Is such a closure at Tula Peak consistent with the evidence from the last two flights and the current situation facing STS-3 that there remains a high probability of utilizing the White Sands Northrup strip as a landing site in the test phase and potentially in future operational flight?

Mr. SMYLIE. I believe that it is. The requirement for the Dakar station is one for supporting the due east launches until the TDRSS is up. Those launches do not fall within the communications capability of Madrid. In the absence of having capability at Dakar, our first data contact after Bermuda would be Hawaii on a due east launch.

In obtaining equipment to incorporate that station in the network, we looked at the total inventory of equipment available to us and Tula Peak equipment appeared to be the most logical in terms of our coordination with the space transportation system people and of their needs. The Northrup strip is still retained as a valid and operable contingency landing site, even in the absence of the Tula Peak station. We will still have UHF air-to-ground capability to provide voice communication, and that capability is consistent with the other contingency landing sites around the world. We have not eliminated the Northrup strip as a Shuttle landing site as a result of removing that station.

Senator SCHMITT. What capability do you lose with the decommissioning of Tula Peak?

Mr. SMYLIE. We lose S-band telemetry and command from Tula Peak, but that is not the mission requirement for a contingency landing site. It is a desirable thing to have, certainly, but it is not required.

Senator SCHMITT. Are you willing to say that it would not in any way bias your prelaunch and prelanding decisions on how you would handle STS-4 or subsequent operational flights?

Mr. SMYLIE. I think that is a question that should more properly be answered by the Shuttle operations elements of the agency.

Senator SCHMITT. Surely they must have answered it in the course of these discussions?

Mr. SMYLIE. I think the answer is that it would not bias the decision to land at Tula Peak if there is a requirement to do so. That is my understanding.

Senator SCHMITT. Not having S-band telemetry might have a very significant impact on where you were willing to land, depending on the situation that may have developed on orbit or during launch?

Mr. SMYLIE. It is my understanding that the absence of the station at Tula Peak does not affect either the ability or the mission planning to utilize Northrup strip.

Senator SCHMITT. Was it considered to utilize the equipment at Edwards that is backed up by the Goldstone capability?

Mr. SMYLIE. Goldstone cannot track below a certain altitude. Below about 20,000 feet we cannot contact the Shuttle from Goldstone.

There is a requirement for the Buckhorn station to acquire postlanding data from the orbiter while at Dryden, utilizing the equipment there to send data back to KSC for a normal mission. Buckhorn is not a dual link station. So, if we took it out, we would lose the capability completely. That was certainly considered in the tradeoff of where to obtain the equipment to build up the Dakar station.

Senator SCHMITT. It is my understanding that the current contract arrangement for TDRSS is under review. What options are you considering in that regard?

Mr. SMYLIE. At this time last year, we were considering three options. One would be just a modest change in the structure of the contract in terms of technical direction and contract direction, and maybe some changes in the incentives of the contract.

The second would be, in effect, an ownership of the system by the Government rather than ownership and lease from a contract.

The third was a dedicated lease in which the shared commercial service portion of the program would be eliminated and the system, although still providing a long-term lease for service to NASA, would be dedicated to NASA use. That third option of the dedicated system is the one that we are considering most seriously at this time; in fact, the only one currently under consideration.

Senator SCHMITT. When would you expect a final decision?

Mr. SMYLIE. It is currently being discussed within the Administration. My target would be to make that decision within the next 90 days or so.

Senator SCHMITT. What has precipitated this review?

Mr. SMYLIE. A number of things that have occurred over the life of the contract. The long delay that we have encountered in bringing the system to an operational status has continuously been a problem between ourselves and the contractor in terms of the implementation of the program, in that every decision made, every change or every new circumstance that arose had to be considered in the light of the effect on that commercial service component of the program. It makes for a very difficult contractual and day-today management arrangement. We believe that, based on that experience, the difficulties would continue right on through the operational phase. From our point of view, as well as the contractors', I believe the shared system has been a major difficulty in the program.

From the contractors' point of view, the ability to market commercial services is affected by the uncertainty of the schedule for it. The program is unique in a number of ways: In terms of the way it is financed; the shared commercial service; the fact that it is a fixed price; the fact that it was a lease for a service at the time that the equipment available to provide that kind of support did not exist. This uniqueness has made the entire program a very difficult contract to manage. I must say at this point, it appears well on its way to being a major technical success. The program is proceeding well technically.

Senator SCHMITT. If you had to do it over again, would you do it this way?

Mr. SMYLIE. I don't believe that we would do it this way if we had to do it again. If it could have been done on the schedule that it was conceived to be done on, it would have brought both the commercial and the NASA service into being in late 1979, or early 1980 and I think it would have been a good program.

Senator SCHMITT. So it wasn't so much the nature of the contracting, it was the unforeseen technical difficulties that prolonged the contracting period?

Mr. SMYLIE. That certainly has been a major factor. I would not recommend a shared system approach again because it is fraught with so many difficulties over the life of the program in terms of the priorities required for a national asset to support all of the U.S. space programs, bumped up against commercial service requirements of the contractor. We are bound to run into conflict over the life of the program and it would be an advantage to both of us, I think, if we could satisfactorily dedicate that system to NASA use.

Senator SCHMITT. It doesn't hurt to learn by experience, so long as you don't have to pay too much for that.

Mr. SMYLIE. What we would potentially gain from that dedication is the effective use of two additional spacecraft because there are six spacecraft in the program. I think over the life of the program the commercial service would effectively use two of them. If we can make that change, then we will effectively have six spacecraft available for NASA over the life of the program, whatever that life may be. It may be much longer than 10 years.

Senator SCHMITT. Looking ahead 20 or 25 years, what do you see as a major technology problem in your area of tracking and data acquisition—in 25 words or less?

Mr. SMYLIE. The problems are opportunities. The assessment of the tracking and data relay satellite system, in terms of meeting the agency's requirements through the early 1990's is quite high that the system that we will bring online should be able to provide that service. Certainly in the future plans of the country satellite programs would operate at much higher data rates than the tracking and data relay satellite is capable of handling. Sometime in the mid- to late 1990's, we would expect to need the capability to handle higher data rates, at least on the space-to-space link. That means going to higher frequencies on that link or possibly even optical communications on that space-to-space link. There is technology development currently underway both in the DOD and in my program to explore those future areas of interest.

In the deep space program, higher data rates will likely be required in the future. The K-band is available as a deep space frequency and we would expect sometime in the future to go first to

X-band for commanding, where we already have X-band for receiving data, and then probably at some future time to K-band for the deep space network.

We have underway studies that would begin to scope what the future tracking and data relay satellite system might be to replace the one that we will initiate next year. We also have some low level studies on what the DSN capabilities might be beyond the year 2000. Up through that timeframe, we believe that the consolidated network that we are planning will serve the agency's needs for planetary and eliptical orbiting programs.

Our next major event in the DSN is the Voyager 2 encounter of Uranus in 1986. Much of our activity is aimed toward having the improvements in the network that are needed to provide satisfactory image and data return from that mission.

Senator SCHMITT. Is there any potential for laser communication in the optical communication area in the deep space environment?

Mr. SMYLIE. That is one of the technologies that we are exploring for the Deep Space Network. We have, as I said, low level studies, one of which is to look at orbiting deep space relay satellite which would be the analog of the tracking and data relay satellite for Earth orbital missions. For that kind of an application, optical communications might be a possibility, but it would be above the atmosphere and would have in effect a space to deep space link. Optical communications is certainly a candidate for that if we should go to that type of application.

Senator SCHMITT. In any of the propulsion systems being considered for turn-of-the-century deep space activity, do you have any radio frequency communication interference problems? Has that been studied?

Mr. SMYLIE. The S-band will get more and more crowded as time goes on.

Senator SCHMITT. I am thinking in terms of specific interferences from the nature of the propulsion system that might be used in deep space.

Mr. SMYLIE. I would have to provide that for the record. I am not aware of anything. That is something that I have thought about, and I am sure somebody in my staff has. We will provide that for the record.

[The following information was subsequently received for the record:]

Electric/Ion engine designs anticipated the possibility of Radio Frequency Interference (RFI) and this was one of the criteria taken into account during the design, manufacture and testing.

RFI from electrical propulsion units to other spacecraft electronic components has not been a major problem and is not viewed as a barrier to their application for use in spacecraft systems. However, to date, these have all been relatively small engines and large engine designs may uncover some unforeseen problems. Space Electric Rocket Test (SERT) 1 launched 1964 and SERT 2 launched 1970 used this type of propulsion system successfully.

Senator SCHMITT. What about rewiring the ground system with optical fibers?

Mr. SMYLIE. We have done some of that. There are optical links linking computers at the Goddard Space Flight Center operating at 50 megabit range by now. We are considering optical links in portions of the DSN.

Senator SCHMITT. What criteria are you using to make those decisions?

Mr. SMYLIE. Primarily cost. With the high data rates required on a computer-to-computer interface, the least costly alternative might be the optical link. Until now, we have been doing it as an experimental thing to understand the technology to see what it has to offer; but I believe it will offer advantages in the future. The initial application at Goddard was at least partially experimental for us to become familiar and skilled in the technology involved in using the optical link.

Senator SCHMITT. I am sure there are also advantages in terms of noise and error rate. Has that been a——

Mr. SMYLIE. Potentially there are advantages there. I don't know that that is overriding in terms of the applications we looked at so far. At least on the computer-to-computer interfaces.

Senator SCHMITT. As I understand the introduction of optical fiber communication from data source to computer at the Los Alamos National Laboratories was based more on the need to have low noise communications than it was on cost. Have you been in touch with that group to learn from their experience?

Mr. SMYLIE. The technology people at Goddard working this have interfaces with Los Alamos. There is some work at KSC utilizing fiber optics at the launch site there as well as some work at JPL in the DSN. The Air Force, of course, has some activity. All of these activities are well coordinated, I believe. I have not personally talked to anybody, but I am aware that Goddard has.

Senator SCHMITT. At this time you would think that the rewiring, as it were, of the ground portion of the network would be based principally on cost differential between optical fiber and conventional means rather than on the basis of improved data collection?

Mr. SMYLIE. Yes, sir, I believe so. I think we can reach an acceptable error rate in the absence of the optical link on most of our links. So, I don't think it is driven by that.

Senator SCHMITT. Could you provide for our record a brief description of the interactions within the data handling community on analyzing the appropriateness of optical fiber communications in these high data rate areas?

Mr. SMYLIE. Yes, sir.

[The following information was subsequently received for the record:]

NASA has and continues to test, demonstrate and utilize fiber optic communications in specialized areas. The aforementioned computer-to-computer interfaces at Goddard Space Flight Center (GSFC) have proved to be extremely reliable. We are coordinating with the DOD on other specialized uses associated with data handling at very high bit rates (50–100 MBS) over relatively short distances (less than 5 kilometers) for interference free, low power and secure uses.

Our plans also call for fiber optic interconnections for 50 MBS spacelab data as well as the high rate Landsat-D thematic mapper data, and for transmission of Space Telescope data between GSFC and Johns Hopkins University.

Within our Communications Network (NASCOM) the use of fiber optics proposed by the authorized communications carriers is based mainly on cost factors as contrasted to technical superiority. The carriers will propose a system which is competitively advantageous and still meet the performance requirements.

Senator SCHMITT. So again, looking at the turn of the century, you see principally doing what we are doing now but doing it better as the technology improves and no major new innovations in the communications area unless it would be the use of space-to-space laser or optical communication?

Mr. SMYLIE. I view the use of optical communications and the higher frequencies as major technological challenges in that sense as innovations. Beyond that, no, sir.

Senator SCHMITT. But they are ones that you have been looking at for at least a period of a few years and you don't know of any major demand that is going to require a whole new technological breakthrough, the nature of which you would have trouble describing today?

Mr. SMYLIE. No, we believe that the technology which we are pursuing would meet those needs and well up into the gigabit range. The data rate is really what drives us.

Senator SCHMITT. Do you see these technological innovations as also enhancing the U.S. position relative to future ITU discussions?

Mr. SMYLIE. Certainly, it is one of our major objectives in the ITU discussions to bring forth those initiatives and those propositions that will allow us to utilize the technology for application as we see that future need.

I believe for us at the last series of sessions that the K-band was made available for the deep space network, which is where we believe we should be headed. That is our objective and we think we are having pretty good success in that.

Senator SCHMITT. What accounts for the decrease in budget for data processing operations?

Mr. SMYLIE. I think part of it is an internal budget transfer of some operational support in data processing that went to the tracking and data relay satellite related budget; about $10 million is involved in that. So, it is not so much a reduction as it was a budgetary transfer from data processing to the tracking and data relay satellite related activity.

Senator SCHMITT. Will we be providing tracking and data acquisition capabilities for the missions to Halley's Comet by the European space agencies and the Japanese?

Mr. SMYLIE. We are in the midst of discussions and negotiations with both of those organizations to provide such support. I am confident that we will provide support to both of those missions, primarily from Australia, on a reimbursable basis.

Senator SCHMITT. So the arrangements would be reimbursable?

Mr. SMYLIE. Yes. Both of those missions would be reimbursable missions.

Senator SCHMITT. Any sharing of data is going to be done on an investigator level rather than agency by agency?

Mr. SMYLIE. I don't know the answer to that in terms of the sharing of data. We could provide that for the record.

[The following information was subsequently received for the record:]

NASA is working closely with the European Space Agency (ESA) on its Giotto mission to Halley's Comet. Thirty-three U.S. scientists are co-investigators on nine of the ten instruments to be flown on the ESA Giotto mission. In each of these cases, there is an agreement that the co-investigator will receive the data for scientific analysis. NASA is providing support to the U.S. co-investigators and that support is contingent on their obtaining an agreement that the spacecraft data will, one year after receipt, be made available to the international scientific community.

Currently, there is no participation by the U.S. scientists on the Japanese Planet-A mission to Halley's Comet, although some preliminary discussions on obtaining data have been held.

Senator Schmitt. I know that is not your area. Would someone discuss that with the science and applications group, see what their plans are there?

Mr. Smylie. Sure.

Senator Schmitt. Are we going to have to make any adjustments, technical adjustments to our network in order to support those activities relative to Halley's Comet?

Mr. Smylie. I don't think there is any capital investment required to support them. They will be compatible with our network capabilities I think at X-band. The cost is the operating cost of the network. If there have to be any adjustments to the network in terms of capital investment then that would be reimbursable also.

Senator Schmitt. Your budget request states that the fiscal year 1983 request provides support to approximately 50 automated Earth orbiting and planetary missions. Is this full support of the 50?

Mr. Smylie. That number 50 would encompass those missions for which we provide launch support only as well as those for which we provide tracking and in addition to data return. So, it is a mix of all of those. Many of them are launch support only for one or a portion of an orbit. I think probably Ariane launches would be in that list, and we provide a very brief amount of launch support.

Senator Schmitt. We provide launch support for Ariane?

Mr. Smylie. Yes, sir; on a reimbursable basis.

Senator Schmitt. Have you made any estimate on how much that launch support subsidizes the Ariane activity since it is a capital investment that they do not have to make?

Mr. Smylie. They pay full reimbursement of all of our costs.

Senator Schmitt. Including amortization of the capital?

Mr. Smylie. Yes, sir; however, in lieu of depreciation of capital, we use sustaining network equipment, costs in the basic user charge in reimbursable agreements with non-Government users.

Senator Schmitt. Has anybody evaluated what would be the onetime cost to the Ariane system if that support was not available?

Mr. Smylie. No, I have not.

Senator Schmitt. I am more than happy to be cooperative with our friends, the French and the European Space Agency, however, this has now become a competition between two launch support systems. Maybe we will have the staff get together and discuss that a little more fully.

Mr. Smylie. It has been essentially our policy from the very beginning that on a reimbursable and noninterference basis with our own programs to provide support to those missions of other countries and other agencies, including commercial missions. And I think that has been a valuable policy to follow over all of these years.

Senator **Schmitt**. I am not sure we have ever been faced with this kind of an intense overtargeted competition that the Ariane provides relative to certain Space Shuttle flights.

Mr. **Smylie**. Yes, sir.

Senator **Schmitt**. It might be worth looking at again, and I will ask the staff to talk with you to develop whatever information is of use to the committee.

Mr. **Smylie**. Surely. We will be pleased to discuss that with you and your staff at length.

[The statement follows:]

STATEMENT OF
R. E. SMYLIE
ASSOCIATE ADMINISTRATOR FOR
SPACE TRACKING AND DATA SYSTEMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY AND SPACE
COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION
UNITED STATES SENATE

Mr. Chairman and Members of the Subcommittee:

It is again a pleasure to appear before this Subcommittee to present the FY 1983 budget request for the NASA Space Tracking and Data Systems Program. I shall also review significant activities since my testimony last Spring and discuss our current and planned activities for providing support services to all NASA flight projects.

As you know, the Space Tracking and Data Systems Program provides vital tracking, command, telemetry, and data acquisition support to meet the requirements for Earth-orbital science and applications missions, planetary missions, sounding rockets, research aircraft, and all phases of the Space Shuttle Program. Two worldwide tracking networks, one for deep space missions and one for Earth-orbital missions, provide this support. A global communications system links tracking sites, control centers, and data processing facilities providing real-time data processing for mission control, orbit and attitude determination, as well as routine processing of telemetry data for applications and scientific missions.

FY 1983 BUDGET REQUEST

For FY 1983, we are requesting a total of $508.9 million to provide for continuation of our vital tracking, command, telemetry, and data acquisition support to meet all of our support requirements for NASA flight projects. In FY 1983, support will continue for ongoing missions along with preparations for Space Telescope, Galileo, Spacelab, and the Uranus Encounter of Voyager 2. A major effort will continue also to consolidate three Spaceflight Tracking and Data Network (STDN) stations with those of the Deep Space Network (DSN) under the management of the Jet Propulsion Laboratory (JPL) in the 1984/1985 time period.

In addition, the FY 1983 budget request includes funds for the initial increment for Tracking and Data Relay Satellite System (TDRSS) services.

OPERATIONS

Program funding of $338.2 million is required for flight support operations and represents the major portion of our total FY 1983 request. The requested amount represents constrained funding and program reductions taken in both FY 1982 and FY 1983, and a continuing evaluation of support requirements. Among the program reductions were the closure of the Quito, Ecuador, and Tula Peak, New Mexico, tracking facilities, the closure of the DSN 26-meter antenna subnetwork, and staffing reductions at a number of tracking stations.

The only significant increases provided for in the FY 1983 request are for a minimal amount of escalation and the funding of activities in preparation for the initiation of TDRSS services in FY 1983. Since our operations are labor intensive, inflation due to personnel compensation has a significant impact on our funding requirements. Also, our tracking station energy cost continues to increase in spite of decreases in consumption through conservation and station closures. In preparing for the initiation of TDRSS service in FY 1983, there are a number of operational activities associated with the TDRSS related ground systems that are crucial to the operation of the total system such as completion of the Network Control Center (NCC) software and the staffing buildups to operate the ground systems.

SYSTEMS IMPLEMENTATION

For Systems Implementation, we are requesting $96.0 million. Funding is required to sustain the existing ground support facilities and systems to support a wide variety of space missions and to provide new capabilities to meet the special requirements of individual flight projects.

Within the sustaining element of the Systems Implementation program, we are continuing a phased replacement of major computer systems at the Goddard Space Flight Center (GSFC), upgrading the communications system at GSFC, conducting a study of future Tracking and Data Relay Satellite System (TDRSS) configurations, and undertaking the development of on-board systems to work with TDRSS.

Systems Implementation funding is required to continue implementation of new capabilities for upcoming missions, including Space Telescope, Galileo, Spacelab and Uranus Encounter of Voyager 2. In addition to the above missions, an extensive effort is underway to consolidate and reconfigure STDN stations with the DSN. The reconfiguration will include the implementation of centralized signal processing facilities at each DSN complex along with an antenna arraying capability. Automation will be designed into these major capabilities in order to maximize the savings in the maintenance and operation of the consolidated network.

ADVANCED SYSTEMS

We are requesting $13.4 million for this vital element in the Office of Space Tracking and Data Systems (OSTDS) program. With the rapid changes taking place in the state of the art in telecommunications and computer technology, there is a continuing need in these areas of technology to assess and apply these advances to mission support. Areas in which such technology can be applied to future mission support include improved navigation accuracies for planetary spacecraft, use of higher frequencies such as K-Band and the digital processing of very high telemetry data rates. It is through such efforts that a crucial technology base is developed and made available for future support capabilities.

TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS)

$61.3 million is included in our FY 1983 request for the payment for the initiation of TDRSS service. TDRSS services are being procured through a long term contract from Space Communications Company (SCC). Funds requested for FY 1983 are to initiate repayment of the construction loan and to make operations and award fee payments to SCC for the services provided. Our current estimate of the NASA cost for the ten year service contract, including development, operations, and interest costs, is $2.3 billion based on the initiation of loan repayments in July 1983.

NETWORK SYSTEMS

SPACEFLIGHT TRACKING AND DATA NETWORK (STDN)

All launch and orbit phase support of Earth orbital missions, including the Space Shuttle, are supported by the STDN. Presently, there are 11 general purpose stations in the network, two Shuttle special purpose telemetry, voice and command stations, and three air-to-ground UHF Shuttle Voice stations. In addition, the Office of Space Tracking and Data Systems has the responsibility for the operation and maintenance of ten laser ranging stations in support of the NASA Geodynamics Program. From these networks, housekeeping applications and scientific data are acquired, processed, and transferred to project control centers and on to experimenters.

Since this time last year, we have reduced our network capability by closing the general purpose station at Quito, Ecuador, and the special purpose station at Tula Peak, New Mexico. In addition to these closures, we reduced personnel at the Alaska, Hawaii, and Merritt Island stations. We anticipate closing the Buckhorn, California, special purpose station when Shuttle landings are targeted to the Kennedy Space Center (KSC) later this year. In addition, our FY 1983 budget calls for staffing reductions at Guam, Ascension Island, and Santiago beginning in October 1982.

The projected workload in FY 1983 which the STDN will support is a bit higher than in FY 1982. We provide both launch and on-orbit support to missions of foreign countries and commercial firms on a reimbursable, non-interference basis. With the reduced support capability, the network will be stressed in meeting the heavy workload.

SHUTTLE SUPPORT

Since my testimony last Spring, the STDN concluded preparations and testing and twice achieved a peak readiness to support the two Space Shuttle missions last April and November. The NASA STDN was supplemented by the United States Air Force site in the Indian Ocean. To insure complete data gathering during the critical launch and landing phases, three Shuttle unique telemetry, command and voice stations were established at Ponce-de-Leon, Florida; Buckhorn, California; and Tula Peak, New Mexico. Special Shuttle air-to-ground voice communications stations were colocated at Intelsat ground stations in Senegal and Botswana, as well as at our laser tracking site at Yarragadee, Australia, and the USAF Indian Ocean station. These latter stations filled in gaps in voice coverage. After STS-2, it was decided that as an economy move, coverage from Quito, Ecuador, could be eliminated and the operations at that station terminated with the last Shuttle pass on November 14, 1981. Likewise, the special purpose station at Tula Peak, New Mexico, was closed the same day due to changing programmatic requirements.

Revalidation and verification of equipment and procedures are currently being performed to achieve readiness to support the STS-3 mission in March.

An agreement was reached with the Government of Senegal which will allow upgrade of the present Dakar air-to-ground voice station to an S-Band telemetry, voice and command station before the STS-4 mission in mid-1982. Efforts are well underway to refurbish and repackage the Tula Peak equipment and establish communications circuits by early June to meet this requirement. Without this change at Dakar, there would be a gap in data coverage between Bermuda and Hawaii for all due East launches which begin with STS-4. This mid-point station will allow analysis of initial orbital maneuvering system burn data and provide for crew updates in the event of any trans-atlantic abort or abort-once-around cases. Crew safety will be enhanced by this added capability in Dakar.

DEEP SPACE NETWORK (DSN)

During the past year, the DSN supported 11 spacecraft in interplanetary travel which included the seven Pioneers, Helios 1, the remaining Viking Lander, and the two Voyagers. The paramount support activity was the very successful Voyager 2 encounter of the Saturnian system which resulted in return of 11,820 images of Saturn and its environment. As was the case during the Voyager 1 encounter with Saturn, the use of antenna arraying greatly enhanced the performance of the deep space stations to receive the signals which traveled over one and a half billion kilometers to Earth. Following its rendezvous with Saturn, Voyager 2 has been placed on a trajectory for Uranus, where it is scheduled to arrive in early 1986.

In addition to the exciting encounter of the Saturnian system, the network supported a number of less publicized, but still notable scientific activities. These included superior conjuctions with the Pioneer 10, 11, and the Voyager 2 spacecraft during which the Sun came directly between the respective spacecraft and the Earth. During the superior conjunctions minor variations in the radiometric data are measured, which allow the scientist to estimate the solar wind velocity and the electron content between the spacecraft and Earth. The network also supported the Helios 1 fourteenth solar perihelion period (near approach to the Sun) activity. During the perihelion, the Faraday Rotation Coefficients are measured from which the variations in the Sun's magnetic field can be derived. All of these events were supported with minimal problems by the network.

Another major factor in the FY 1983 submission was the closure of the 26-meter antenna stations in December 1981. This action was taken to reduce FY 1983 costs. A reevaluation of flight project requirements after the Voyager 2 encounter of Saturn confirmed that the 26-meter stations could be closed with the DSN still providing adequate support from the remaining 34- and 64-meter antenna stations.

COMMUNICATIONS

The NASCOM Network is a generic term referring collectively to the circuits, switching and terminal facilities arranged in a global system established and operated by NASA to provide long haul operational communications support for all NASA projects. NASCOM interconnects such facilities as NASA's foreign and domestic tracking and telemetry acquisition sites; launch areas; mission and network control centers.

NASCOM uses, in most instances, full period circuits or services obtained through lease from 16 domestic and 10 foreign carriers, using a variety of their communications satellite, terrestrial cable, microwave relay, and submarine cable facilities. The overall management of NASCOM is centered at the Goddard Space Flight Center (GSFC).

The Communications support of the Space Shuttle (STS-1 and STS-2) missions was highly successful. Installation, test, and verification continues on the performance of the 50 megabit wideband data handling equipment for the Tracking and Data Relay Satellite System (TDRSS). This system between GSFC, Johnson Space Center (JSC) and the facility at White Sands, New Mexico, will be used to support all low orbiting spacecraft when the TDRSS becomes operational.

During the first quarter of FY 1983, a 50 megabit circuit will be activated from the White Sands ground terminal to JSC and GSFC. This capability will be used to meet the high data rate requirements for Spacelab and Landsat-D.

Work will be initiated to conduct operational tests of a multiple access mode of operation using existing domestic satellite transponders. This mode will provide a greater transfer of data over the same transponder capacity. This will increase the effective use of the transponder capacity without increasing the cost to the user. Work also is continuing at GSFC for relaying high rate computer-to-computer data transfer via fiber optic distribution systems.

CONTROL CENTERS

Currently, we operate five control centers for the monitoring, command, and control of some 20 spacecraft. In addition, a new control center is being implemented for the Space Telescope. Funds are requested in FY 1983 to continue the development and installation of the Space Telescope Control Center hardware and systems software. Also in FY 1983, funds are requested to continue the software activity necessary to support the high precision target pointing, command management, mission scheduling, attitude control and operation of the several instruments on-board the Space Telescope. Initial control center testing with the flight experiments hardware will also take place in FY 1983 in preparation for the FY 1985 launch.

Upgrading of the Multisatellite Operations Control Center (MSOCC), a single facility which is controlling 10 existing spacecraft, will continue. This control center will also be the operating facility for future new spacecraft such as Earth Radiation Budget Satellite

(ERBS). MSOCC utilizes pooled facilities from which selected equipment and computers are electronically connected to support each spacecraft pass. After the pass, the selected equipment is released and becomes available for other spacecraft passes. By using the same equipment to sequentially support different spacecraft, the upgraded MSOCC will be capable of supporting 15 to 20 spacecraft depending upon the monitoring and control requirements of each spacecraft. The majority of the hardware has been purchased. In FY 1983, it is planned to procure the necessary interface equipment to network the major MSOCC computers for the exchange of data and programs and to procure a processor for software development and post pass spacecraft verification and analysis.

SUPPORT COMPUTING ACTIVITIES

Activities in this category are directed toward providing near-real-time support to spacecraft operations such as orbit determination, attitude determination, maneuver computation and command management, and indirect support for such vital functions as scheduling and modeling. The large computer complex which provides this support is about 16 years old. Increasing failure rates affect its operational capability and reliability thereby jeopardizing mission success. Extra expenditures to ensure mission success have been initiated to bring in vendor engineers to be continuously available during critical support to STS and expendable launch vehicles. This procedure will remain in effect until the replacement systems become operational.

A sequential replacement of several computer systems has been undertaken. In FY 1979, funds were made available to replace the Metric Data Facility (MDF) which is currently undergoing acceptance testing and will become operational in March 1982. Because of unacceptable vendor response to the RFP for the Flight Dynamics System (FDS), a delay was necessary to restructure the acquisition strategy. An RFP based on lease with option to buy will be released early in 1982 with a planned operational date in mid 1983. The third computer system to be replaced, the Command Management System (CMS), was deferred from FY 1981 to FY 1982 at the time the amended FY 1981 budget was submitted. Funds for this system have been programmed in FY 1982, but at a reduced level in the amended FY 1982 budget. This reduction necessitated a change in acquisition strategy from purchase to lease with option to purchase. The fourth computer system to be replaced is the Orbit Computation System (OCS), and acquisition will be initiated in FY 1983.

The Operations and Maintenance (O&M) of this large computer complex will be conducted under a contract awarded in FY 1982 for a period of five years. In addition, the associated programming, computation, and analysis activities will continue under a new contract to be negotiated in FY 1983.

DATA PROCESSING

Another very important support function provided by OSTDS is the processing of bulk science data from various spacecraft. Traditionally, the receipt, capture, accounting, and product generation activities have been classified broadly into two major categories, image and telemetry (non-image) data processing. The Image Processing Facility (IPF) converts the data from measurements made by the spacecraft of

Earth features or phenomena into pictures or their digital representation on computer tapes. In telemetry data processing, the science data is separated for the individual investigators and recorded on experimenter tapes. Also plots or histograms may be produced. A major subset of the telemetry data processing activities in the future will be the processing of data from Spacelab missions by the Spacelab Data Processing Facility (SLDPF) which is currently under development.

As indicated previously, the IPF was designed to process data from Earth sensing application missions. Currently, the facility processes data from Landsats 2 and 3, Heat Capacity Mapping Mission (HCMM), and Nimbus spacecraft. The facility is meeting and, in some cases, exceeding production levels required by the users because of improvements made to the facility production systems in FY 1981. FY 1983 funds will be utilized to continue the operation to process the large number of retrospective orders being received from the Department of Interior.

The Telemetry On-Line Processing System (TELOPS) serves as the input processor for telemetry data. Its associated output processor, the Univac 1100/82 computer, will also provide the output processor function for the Spacelab Data Processing Facility which will be discussed later. In FY 1983, tape and disc units will be added to this computer to improve its reliability and efficiency in the dual output processor role.

Currently, telemetry data is time division multiplexed with the concept of generating packetized telemetry data, instead, for reduced ground data processing complexity and shorter delivery time to the user or experimenter. The purpose of the packetized telemetry is to provide the required ancillary data with the bulk science data at the data source and avoid the merging of these data in the ground data processing system. The Space Telescope will be the first mission to use some of the concepts of packetized telemetry. FY 1983 funds are required for the continued development of a data capture facility to receive, error check, and forward data to the Space Telescope Science Institute.

Also, funds are required in FY 1983 to continue the development of the Spacelab Data Processing Facility (SLDPF). The Spacelab missions will generate very complex data streams consisting of analog, audio, instrumentation, and variable rate digital data. An all new input processor (hardware and software) is required to capture, quality check, account for, preprocess, and generate output products for the European Space Agency (ESA) and U. S. investigators. The data capture capability for SLDPF is greater in magnitude than that required initially in the TELOPS design for free flyer spacecraft.

TRACKING AND DATA RELAY SATELLITE SYSTEM (TDRSS)

The TDRSS, as you know, will consist of an operational constellation of four spacecraft in geosynchronous orbit, a ground terminal located at White Sands, New Mexico, and scheduling and communication facilities at the GSFC. Of the four spacecraft, two will be dedicated to NASA service; one will provide commercial service; and the fourth will serve as a shared spare to maintain both services.

During FY 1983, we plan to conduct two launches and establish the initial operating capability.

This satellite constellation will provide ten years of satellite service to NASA under the terms of the contract with Space Communications Company (SCC), a partnership of subsidiaries of Western Union, Continental Telephone, and Fairchild Industries. During the development phase, TRW and Harris Corporation are major subcontractors to SCC for the space and ground segments respectively with TRW also responsible for overall systems integration.

Since my last appearance, a number of significant program milestones have been accomplished. The first spacecraft has completed its environmental test program. Vibration, acoustic, and pyroshock tests were completed, demonstrating successfully the ability of the spacecraft to withstand the extremes of the launch environment, spacecraft separation, and appendage deployment. In addition, a lengthy thermal vacuum test of more than 50 days was completed, providing design verification for the spacecraft, antenna, payload modules and the large, single access antenna compartments.

While some minor problems did occur during the thermal vacuum test, no major design problems were encountered, and the spacecraft performed admirably.

At this time last year, I shared with you some technical concerns involving the solar arrays and the Travelling Wave Tube Amplifiers (TWTA's). Both of these major elements now are performing well. The solar array design has been modified to relieve thermal stress and final testing of the revised design is underway. The TWTA manufacturing processes have been altered, resulting in the production of better quality tubes with the high reliability necessary for an extended service period.

In 1979, NASA and the DOD jointly studied the security issue associated with the TDRSS operation. In 1980, the TDRSS contractor initiated Phase A of an implementation to install National Security Agency (NSA) provided equipment into the TDRSS spacecraft. In June 1981, the United States Air Force (USAF) recommended termination of this effort due to technical cost and schedule concerns.

NASA, NSA, and our contractors then proceeded with the study of an alternate approach which is now being implemented. This approach involves the installation of currently available hardware. We are also in the process of modifying the ground station to increase the transmitted power to the spacecraft. This combination greatly enhances the operational utility of TDRSS to all users.

To meet DOD security requirements associated with the TDRSS scheduling and control, facilities at GSFC and the required communications links are being secured. This effort is being implemented by NASA and is funded by the DOD.

The TDRSS ground terminal is progressing well. At this time last year, consideration was being given to substituting more capable computers in the ground terminal to forestall operational problems and incorporate security changes. Last summer, that substitution was made and the new data processing equipment has been installed and integrated. Software debugging and service level testing for the ground terminal are continuing. Initial data flow and compatibility testing between NASA systems and the ground terminal have been initiated. Testing for the baseline software and hardware will be completed this Spring when testing of security modifications to hardware and software will be initiated. Verification and failover testing will be completed by September, and systems and interface testing for launch and flight operations will be initiated in October.

Several NASA systems are integral to the delivery of user support services via TDRSS. Key elements are: the NASA Ground Terminal (NGT), the Network Control Center (NCC), and the associated computing and interconnecting communications systems. These systems are in various stages of delivery, installation, and test and are, for the most part, progressing well.

At the NGT, colocated with the TDRSS ground terminal at White Sands, New Mexico, the fault isolation and monitoring system software and hardware testing is underway. This system will monitor TDRSS service performance and provide the capability to isolate service failures and rapidly restore user services when failures occur. It is scheduled to complete its testing this April.

The NCC controls the scheduling of the TDRSS services. Some difficulty has been experienced in the readiness of this facility primarily in software availability. This system has been reexamined over the past year and a modified hardware/software approach that provides an initial operating capability is now being implemented. This system will be upgraded as the numbers and types of TDRSS users increase. In addition, a simplified backup capability is being provided as an alternate interface to the White Sands station.

There will be increased activity this year in the area of launch preparation and mission planning for the TDRSS. As you know, TDRSS will be the first launch of the Inertial Upper Stage (IUS) from the Shuttle. Our mission preparation and planning will be dealing with the first launch of Orbiter 099, the first IUS, and the first TDRSS spacecraft, making it an extremely complex mission. It requires a great deal of coordination and detailed planning since the Shuttle will be controlled from the Johnson Space Center (JSC), the IUS from the U. S. Air Force control center at Sunnyvale, California, and the TDRSS from White Sands.

STATION CLOSURE AND NETWORK CONSOLIDATION

As a continuing effort to achieve economies, we terminated our use of the Winkfield, England, station in October 1980; ceased operation at Rosman, North Carolina, in January 1981; deleted links in Alaska and Greenbelt, Maryland, in 1980; and closed the stations at Quito, Ecuador, and Tula Peak, New Mexico, in November 1981 and reduced staffing at several stations. We anticipate closing the station at Buckhorn, California, when Shuttle landings are targeted to KSC later this year. The closure of these links represents a reduction of about 31 percent in network telemetry, tracking, and command capability. Correspondingly, acquisition time has decreased 40 percent while the number of on-orbit spacecraft has decreased about 18 percent since 1978.

When the TDRSS achieves operational capability in 1984, Earth orbit spacecraft will be supported by this system. This will permit closure of the STDN network stations located in Guam; Hawaii; Santiago, Chile; and Ascension Island. Operations at the special purpose Shuttle stations at Dakar, Senegal; Gaborone, Botswana, and Yarragadee, Australia, will be terminated.

The Alaska station will support Landsat and Nimbus satellites through October 1984, when responsibility for that station will be transferred to National Oceanic and Atmospheric Administration (NOAA). The three STDN stations in California, Spain, and Australia will continue to support highly elliptical and geosynchronous spacecraft which are beyond the TDRSS view from synchronous orbit, as well as provide backup support for Shuttle and TDRSS in emergency situations. The Greenbelt, Maryland, tracking station will be retained until support for the International Ultraviolet Explorer (IUE) is ended. The Bermuda and Merrit Island tracking stations will be partially deactivated in 1984, and will support only launch and landing tasks.

As mentioned earlier, we are continuing with our activities to consolidate the three remaining STDN stations in California, Spain, and Australia with the DSN stations at these locations under the single management of the Jet Propulsion Laboratory (JPL). A new 34-meter antenna will be added to the DSN complex at Goldstone, California, and also at the DSN complex at Canberra, Australia. Later, one antenna from each of the STDN stations in Australia, Spain, and California, will be relocated and integrated into the DSN complexes. These relocated antennas will be used for Earth orbiting spacecraft that cannot be supported by TDRSS. Each station complex will have a shared signal processing facility that will provide centralized monitor and control capability for all the antennas, including all of the digital electronics required for uplink command encoding and downlink demodulation and recording. This shared facility plus centralized maintenance and support services at each complex will provide a great economy of operation.

At the completion of the consolidation activities in 1985, each of the DSN complexes will have the capability to support combinations of deep space probes or Earth orbiting spacecraft outside the viewing constraints of TDRSS. The 64-meter and 34-meter antennas at each site will have a capability to be arrayed in order to effectively increase the aperture available.

AERONAUTICS AND SOUNDING ROCKETS

The Space Tracking and Data Systems Program provides tracking, data acquisition, communications, command and control, and data processing support for aeronautical research and scientific sounding rocket and balloon activities conducted under the direction of GSFC at the Wallops Flight Center (WFC) in Virginia, and the Dryden Flight Research Facility (DFRF) in California, which is under the direction of the Ames Research Center. In addition to supporting these research and science activities with fixed facilities, we maintain a capability at WFC to provide tracking and data acquisition support at remote locations using mobile instrumentation. At WFC, impact prediction and range surveillance activities are supported as a part of the range safety functions.

Plans for FY 1983 include the continuation of the tracking and data support of the aeronautics, sounding rocket, and balloon activities conducted by the WFC and the continuation of a phased program of equipment modernization.

The activities supported at DFRF are related to aeronautical flight research in all flight regimes, with emphasis on high performance flight research, including use of Remotely Piloted Research Vehicles (RPRV). We also provide for the acquisition, processing, display, and distribution of mission test information through the use of telemetry, communications and space positioning systems which comprise the principal aeronautical test range facilities at DFRF.

Flight research activities for FY 1983 and beyond at DFRF are expected to increase and plans are being implemented which provide for upgrades of equipment to keep pace with new requirements. Basic improvements in FY 1983 will continue to be directed at enhancement of telemetry data processing capability along with limited improvements in the long-range optics capability and processing and display of tracking information.

Space Shuttle operations are also supported by the OSTDS facilities at WFC and DFRF which have been configured to meet these requirements. At WFC, the radar and command systems will provide support for the launch phase of the Shuttle missions and DFRF will serve as a secondary landing site for the Shuttle.

ADVANCED SYSTEMS

Our Advanced Systems Program is a relatively small, but vital portion of our program. It provides for technology assessment and application of new technology to future support capabilities that are cost-effective and reliable. It recognizes the tremendous advances taking place in the state of the art in telecommunications and computational technology and the growing need to assess and apply them to mission support. The request for $13.4M for this effort allows for a minimal increase due to inflation. The work is accomplished at the Goddard Space Flight Center for Earth satellite missions and data systems and at the Jet Propulsion Laboratory (JPL) for the deep space missions.

Work includes, for example, extremely precise tracking technology for determining mission angular direction and for measuring time with an accuracy sufficient to track and guide future planetary missions and, as a spin-off; make possible new ground based science experiments, such as, search for gravity waves. Also being pursued is effort aimed at the use of Very Long Baseline Interferometry (VLBI) measurements for the Galileo mission in 1985. Work will continue on development of telecommunications technology, exploring new areas of the frequency spectrum to reduce interference and improve performance. These efforts will improve efficiency, increase the amounts and types of data that can be obtained from deep space missions and correspondingly increase the potential science value of all future investment in planetary missions.

Similarly, for possible future Earth orbital missions during the TDRSS era, data acquisition and processing capability would need to be improved to meet potential requirements of up to 300 million bits per second. The main drivers would be the demands of high resolution sensors such as multispectral scanners, multilinear imaging arrays, and synthetic aperture radars.

New systems and techniques are being pursued to address the transfer of such large volumes of data. These include computer assisted operations, digital processing of high volume data, improved man-machine interfaces and wide band satellite communications to distribute data to processing centers and users. Optical disc storage and automated quality control of data will be investigated to facilitate handling image data processing requirements anticipated for future Earth observation missions.

CONCLUSION

In summary, our mission support capability has been reduced in both the STDN and DSN. Nevertheless, we have successfully supported flight program requirements as exemplified by the excellent support to the Voyager 2 Encounter and the first two Space Shuttle missions. I would like to emphasize, however, that the networks will be strained to their limits in FY 1983 to meet the mission support workload requirements.

The key elements reflected in our FY 1983 budget request of $508.9 million are to provide continuing support to ongoing tracking, command, and data requirements of Earth-Orbital, planetary, and Space Shuttle missions, as well as to the implementation of the networks consolidation program. Preparations and mission planning are underway with two TDRSS launches planned from the Space Shuttle in FY 1983, leading to a full operational capability in 1984.

I urge the full support of this subcommittee for this constrained FY 1983 funding request to meet these essential and vital support requirements.

Mr. Chairman and members of the subcommittee, this concludes my statement. Thank you for this opportunity to present NASA's Space Tracking and Data Systems Program. We are now prepared to respond to your questions.

Thank you.

Senator SCHMITT. Senator Reigle has a statement. I don't believe he has any questions for you. And we will, as soon as he has completed, we will call our next witness.

Senator RIEGLE. Thank you, Mr. Chairman. There have been hearings over on social security disability occurring on the House side this morning to which I have been testifying. That is what has kept me away from here until now.

Let me just say, first of all, that I want to take this opportunity, Mr. Chairman, to commend you for the fine job that you have been doing in chairing this subcommittee. I think your leadership in the field of science, technology and space has insured that these areas are now given the special attention that they deserve.

I share your concern about the future of a number of NASA programs as well as your conviction that we as a Nation must not lose our worldwide competitive edge in the areas of science, technology, and space.

The hearing today centers upon a variety of issues, including space research and technology. These areas are of interest to me because of their impact on many of our Nation's industries. A healthy research and technology program is essential to maintaining our lead in these important industrial sectors.

Many of our achievements in the development of communications satellites have been largely the result of the initiatives begun by space research and technology programs. These programs must be encouraged if we are to meet the challenges of the future.

So I look forward to the testimony from our witnesses and those that have thus far spoken in light of the link which NASA provides between the cutting edge of technology and the day-to-day operations of a number of vital industries. I think it is imperative that we carefully consider providing the necessary investments for these programs. And once again, Mr. Chairman, I want to commend you for taking the lead in this area.

Senator **SCHMITT**. Thank you. I appreciate those kind words and your attention to these activities.

Our next witness is Billie McGarvey, Director of facilities.

STATEMENT OF BILLIE McGARVEY, DIRECTOR OF FACILITIES, NASA

Mr. **McGARVEY**. I do have a brief statement that I would like to summarize, Mr. Chairman.

I appreciate this opportunity to appear before you today to present the NASA fiscal year 1983 construction of facilities budget request. Our request totals $100 million as compared to $104.8 million requested in fiscal year 1982. Although the program is not large, it is a vital program that provides the contractual services for necessary repairs, rehabilitation modification, construction of new facilities, and the planning and design of facility projects which support the research and development and testing activities of the agency.

The NASA physical plant represents capital investments of over $7 billion and a replacement value of more than $20 billion. It is comprised of unique aerospace research, development, test, and operational facilities and equipment. Our fiscal year 1983 request has been structured to meet a continuing objective of preserving and enhancing the capabilities and usefulness of this physical plant. The program is a lean but balanced response to requirements which exceed the funding limitations dictated by today's economic environment.

Prior to addressing the details of the budget request, I would like to update you on the status of some selected projects that have been high interest items in prior years. The two large aeronautical facilities projects costing $85 million each are now nearing completion of construction. The national transonic facility at Langley is approximately 95 percent complete and should be completed in July leading to full operations by the end of this calendar year.

Likewise, the modifications of the 40- by 80-foot subsonic tunnel at Ames are approximately 95 percent complete with the repowering of the 40- by 80-foot tunnel circuit completed and the new 80 by 120-foot test leg addition 90 percent complete at this stage. Construction should be completed in mid-1982 and the facilities should become operational in late 1982. Barring any unforeseen major developments, major we anticipate that future updates to you will be in terms of research being accomplished and results achieved.

The second item of continuing interest pertains to the Shuttle launch facilities at Kennedy. The facilities supporting the first two launches have performed flawlessly and have suffered very little damage. We are particularly pleased that repair or renovation of launch facilities have not been pacing items affecting turnaround activities between flights.

A final update item is the status of our energy conservation program. As you will recall, NASA established a goal of reducing the consumption of utilities energy by 50 percent by fiscal year 1985 as compared to a fiscal year 1973 baseline. This goal has provided the incentive for developing energy retrofit projects and improving facility operations. A 40-percent overall reduction was sustained in fiscal year 1981 despite increased energy needed for the Shuttle operations. We are requesting $23,145,000 for Shuttle and payload facilities with the major projects located at Kennedy Space Center and the Michoud assembly facility. The modifications of solid rocket booster [SRB] refurbishment and subassembly facilities at KSC, estimated to cost $1,700,000 are required to support the flight rates projected in fiscal year 1984 and subsequent years.

Experience with the first two Shuttle flights and related SRB studies have shown that additional capabilities for refurbishing and assembling forward and aft skirts, frustrums, and nose cones are required. The project includes the relocation of forward assembly buildup areas within the low bay of the vehicle assembly building [VAB], the installation of five new curing booths, and the relocation of small shops from the VAB and from the hypergol maintenance facility.

A second project at KSC, estimated to cost $1,740,000, is for the rehabilitation and modification of facilities for payload ground support operations. These are required to meet safety standards and codes for the Delta spin test facility and explosive safe area-60, which are essential spacecraft servicing facilities. Modifications are also required to provide payload-to-user data cabling in the operations and checkout building, provide cabling connecting the communication centers on KSC and Cape Canaveral Air Force Station, and to modify the O. & C. Building to provide a dedicated area for astronaut preflight physiological testing

The largest Shuttle facility requirement is the modification of manufacturing and final assembly facilities for external tanks at Michould in the amount of $17,845,000. This project continues work funded in fiscal year 1982 and prior years. Current evaluations based on the thermal protection system [TPS] application experience to date have revealed the need for two additional TPS spray cells for LO_2 tanks and intertanks to achieve necessary increases in production rates.

The addition of a new 75-ton bridge crane in the vertical assembly building is also necessary to support future production schedules and eliminate a single point of failure. The main manufacturing plant will be modified to provide a 45-foot clear aisle the full length of the building to alleviate material and component crossflow and backflow congestion. Also, the overload crane system in the liquid hydrogen tank welding area requires upgrading to support increased production rates. TPS closeout operations on external flight hardware attached to the external tank require modification of those areas to provide a necessary controlled environment.

To enhance the utilization of our unique NASA aeronautical facilities, a total of $24,615,000 is requested. One of the most critical requirements is the need for a consolidated data analysis facility at the Dryden Flight Research Facility estimated to cost $4.5 million. The facility is required to house new computers and ancillary equipment and consolidate the data automation activities at Dryden in an adequate facility. The largest aeronautics facility project is a proposed $9 million modification of the transonic dynamics tunnel [TDT] at Langley. The TDT is used by both Government and industry for research testing to verify flutter and other aerodynamics characteristics of high speed aircraft designs. The TDT's special features include the flexibility to use either dense Freon-12 gas or air as the test medium. The heavy demand for these capabilities has resulted in a current backlog in excess of 2 years. The major requirement is to improve the capability for scaling the ratio of aircraft mass to air stream density. The proposed modifications will permit increasing the test medium density by 50 percent, thereby greatly increasing the tunnel's capability for accurately scaled testing of heavy models. The major cost elements are the upgrading of the 20,000 horsepower drive system by 50 percent, providing additional cooling, and modifying power and control systems.

A second tunnel project at Langley is the modification to the 4 by 7-meter low speed tunnel estimated to cost $7.2 million. A 2-year backlog of test requirements for this tunnel also exists. These modifications are required to improve the tunnel flow quality and increase productivity. The modifications will include doubling the size of the model preparation areas and building new model support carts to ease model preparation and checkout; developing a rotor test area; enlarging the control rooms, and improving the tunnel circuit flow. These modifications are anticipated to increase useful test time approximately 17 percent.

One other major aeronautical project is the modification of the 450 psi air system at Lewis estimated to cost $2,920,000. This system provides compressed air to the majority of propulsion test facilities at Lewis. The present compressor is over 30 years old, subject to major breakdowns, and must be replaced to provide necessary reliability and continued operations.

The rocket engine test facility at Lewis currently provides for sea-level testing only of low thrust chemical rocket engines. Modification of the facility to provide altitude testing that will simulate the space environment is required. The estimated cost is $995,000 to provide an altitude exhaust system and permit high altitude simulation.

The last discreet or major project I will address is a $2,150,000 rehabilitation project at the Wallops Flight Center which is required for resurfacing and repairing portions of the airfield runways and taxiways. The work is needed now to preclude aircraft damages due to engine ingestion of pavement debris, to prevent further pavement degradation and reduce airfield maintenance and repair costs.

Completing our budget request for fiscal year 1983 is $39 million for repair, rehabilitation, modifications, and minor construction, and $8.25 million for facility planning and design.

Repair for facilities, not in excess of $500,000 per project, totals $15 million; $20 million is requested for rehabilitation modification projects under 500 per project. The third element is the minor construction projects not in excess of $250,000 each which is for $4 million in this category.

In summary, Mr. Chairman, this $100 million budget request for NASA facilities work is a very lean program which addresses our most urgent facility requirements for carrying out the principal research and development and testing activities and provides for the highest priority repair and rehabilitation needs. We sincerely appreciate your support of our facility programs in the past and request your favorable consideration of the fiscal year 1983 request.

I would be happy to attempt to answer any questions, sir.

Senator SCHMITT. Thank you, General.

You mentioned new altitude rocket test facilities at Lewis. Are these in any way comparable to the facilities that exist at White Sands?

Mr. MCGARVEY. To my knowledge, it is not, Mr. Chairman It has a low altitude capability. At this time, it is an existing stand and it is simply a modification project to add the high altitude capability by adding an altitude exhaust system.

Senator SCHMITT. Would you supply us for the record a comparison of the rocket test facilities at White Sands with those projected there at Lewis and the ones that you are projecting to build there?

Mr. MCGARVEY. Yes, sir.

Senator SCHMITT. I am not even sure that White Sands test setup is still in operation.

Mr. MCGARVEY. I do not know. I will have to provide that information for the record. The only test stands that we have operated, to my knowledge, is this one at Lewis plus the Shuttle engine test stands at NSTL and one at Santa Susana, Calif., in the 3 years that I have been with NASA.

Senator SCHMITT. Provide us that information, plus the status of those facilities as potential operational test facilities.

Mr. MCGARVEY. We would be glad to, sir.

[The following information was subsequently received for the record:]

The propulsion test facilities at White Sands (WSTF) are operational and are being used to test Shuttle orbiter maneuvering engines (OME) and reaction control systems (RCS). This testing is scheduled to continue through CY 1984.

The test facilities at WSTF are not suitable for the type of testing planned to be conducted in the Rocket Engine Test Facility (RETF) at Lewis. The high altitude capability of the test stand at WSTF drops to less than 120,000 feet under steady state test operations. The RETF at Lewis as modified, will have a 180,000-foot altitude capability for the full 90 minute long duration testing that is required. The WSTF capability of up to 15,000 pounds thrust is a liability in the context of the low thrust (100 to 1,000 pounds), long duration testing requirement. The large volume (33,000 cubic foot) chambers required for the high thrust work at WSTF cannot simulate the high altitude through a high altitude exhaust system for long duration testing. The costs of modifications and operation to do this would be exorbitant. It is a simpler, lower cost matter to achieve this capability with the RETF at Lewis which has a test chamber of 200 cubic feet which is suitable for low thrust testing. Also, the RETF presently has the high pressure cryogenic run tanks (liquid oxygen and liquid hydrogen) that will feed propellants to the test engines at a sufficient pressure level. At WSTF, the portable dewars that serve this purpose do not have a high pressure capability because the typical higher thrust test engine has its own pumps for this purpose. To provide the required high pressure cryogenic run tanks at WSTF, the estimated cost would exceed $3 million.

Senator SCHMITT. What is the current status of the modifications of the space flight operation facility at the Jet Propulsion Lab?

Mr. MCGARVEY. As you will recall, Mr. Chairman, we had $9,300,000 in an appropriated fiscal year 1982 project, which was the first phase to modify and reconfigure that facility. In the fiscal year 1983 budget deliberations we were not able to accommodate the second phase of the project, which was an $8.5 million phase. Therefore, we have not proceeded with the first phase and have limited our ourselves to only the highest priority safety modifications. The fiscal year 1982 operating plan now contains $1 million in order to satisfy some of the safety problems in the SFOF at JPL.

Senator SCHMITT. When would you expect to undertake the broader modifications?

Mr. MCGARVEY. The reduction in the planetary exploration program in fiscal year 1983 was one of the programmatic drivers that caused the second phase not to be included in the fiscal year 1983 budget. Until there is a buildup in that program, I expect that, in my personal opinion, we would continue to defer this work until there was a programmatic need.

Senator SCHMITT. These modifications are not tied to the Galileo mission?

Mr. MCGARVEY. No, sir, they are not tied to any specific mission. They were tied strictly to safety requirements, improving the operations of the overall facility, and for the future support of planetary exploration programs.

Senator SCHMITT. Are you confident that we are making adequate investment in Shuttle facilities to make it a truly operational system in the timeframe in which it is projected to be operational?

Mr. MCGARVEY. I think, Mr. Chairman, as the system matures, we are learning that, particularly on the payload handling side and handling hazardous cargo and payloads that we probably have overlooked some requirements that will require further investments in the way of facilities. We have some of those under consideration for the fiscal year 1984 program, particularly for hazardous cargo processing and for payload handling, which we have not addressed before.

On the launch side of the question, in order to achieve flight rates beyond 24 per year, I think we will certainly be confronted with activating a third mobile launch platform at some time in the near future.

At the Michoud external tank production plant, there are still rearrangements to be made in the plant layout and improvements in order to reach production rates beyond 24 per year.

Senator SCHMITT. Do you feel confident that the existing facilities, with the exception of the hazardous cargo handling, can support 24 flights a year?

Mr. MCGARVEY. No, sir.

Senator SCHMITT. Existing or those that are in the budget?

Mr. McGARVEY. That are in the budget now? No, sir. Our latest assessments show that we cannot achieve the 24 flights per year without the third mobile launch platform. I think it will be a high priority item for us in the fiscal year 1984 considerations. The assessments by our people at KSC do not indicate that they can reach 24 per year without the third mobile launch platform.

Senator SCHMITT. If that were a 1984 approved item, when would it be available?

Mr. McGARVEY. I would have to supply it for the record to correctly do it, but approximately a 2½-year timeframe from the time we awarded the construction contract. It is about 1½ years of construction modifications and about 6 to 9 months of activation for flight peculiar hardware and equipment.

[The following information was subsequently received for the record:]

If modification of the third Mobile Launch Platform were a Fiscal Year 1984 authorized and appropriated project, it is anticipated that it would be ready for use in the latter part of CY 1986. The planning schedule includes approximately two years for construction and six to eight months for activation.

Senator SCHMITT. So you are saying the earliest we can make a 24 per year launch schedule would be late 1987 or early 1988?

Mr. McGARVEY. Yes, sir. The present schedule that the agency is working is to attain 24 flights per year by, I believe, fiscal year 1988. Yes. That is correct. The present mission model is to achieve 32 flights cumulative through fiscal year 1985 and achieve a rate of 24 per year in fiscal year 1988.

Senator SCHMITT. But that is, you say, dependent on a fiscal year 1984 start on procuring a third mobile launch system?

Mr. McGARVEY. Yes, sir, that would be a big determinant in achieving 24 flights per year.

Senator SCHMITT. Are there any other facility determinants? Any bottlenecks in that rate?

Mr. McGARVEY. At the Michoud assembly plant, there are some other facilities that will be required in the fiscal year 1984 timeframe in order to achieve 24 flights per year. Facilites authorized in fiscal year 1983 and prior budgets will not get us to the 24 per year rate.

Senator SCHMITT. Can the VAB support that flight launch as presently configured?

Mr. McGARVEY. Yes, sir, when the additional high bay that would accommodate the second mobile launch platform is activated. It is scheduled to be activated in the early 1983 timeframe. The current assessments of the two high bays show that they can support the 24 per year.

Senator SCHMITT. Are both of the tractors in operation now?

Mr. McGARVEY. Both of the——

Senator SCHMITT. Of the big transporters.

Mr. McGARVEY. Yes, sir.

Senator SCHMITT. We didn't use one of them for a number of years, isn't that correct?

Mr. McGARVEY. I don't know. I would have to look that up.

[The following information was subsequently received for the record:]

The second transporter has been reactivated and has been available for use since February 1982.

Senator SCHMITT. It has obviously been reactivated. If that is true, it has been reactivated and is operating satisfactorily?

Mr. McGARVEY. Yes, sir. You may recall in the 1980 program we had a facility project for the maintenance of those crawlers. That is operational now and the crawlers are being maintained in that facility at KSC.

Senator SCHMITT. Do you have a coordinating team that works with the Air Force in the Vandenberg construction activities?

Mr. McGARVEY. I don't have one at the headquarters. My counterparts in the facilities engineering office at KSC work very closely with the people at Vandenberg and with the Space Systems Division people in Los Angeles. There are a lot of interchange meetings, and our people visit the launch facilities at Vandenberg quite frequently on the facilities side of the house as well as on the program side of the house.

Senator SCHMITT. Is it your assessment that the Air Force is proceeding with that construction on a doable schedule?

Mr. McGARVEY. Yes, sir. I think the last assessment that I have seen in a briefing by the Air Force is that they are reasonably confident that they will meet their activation date of October 1985 for the first flight at Vandenberg.

Senator SCHMITT. How many mobile launch structures will they have at Vandenberg?

Mr. McGARVEY. Sir, they have an entirely different configuration. They do not have a mobile launch platform similar to the ones that we have at Kennedy. They have a launch pad and a structure where they assemble the orbiter, the external tank, and the SRB's on the launch pad itself. There is only one launch pad.

The flight rates at the moment, the highest rate is 6 per year on the current schedule.

Senator SCHMITT. Is the way we are making investment in facilities the way a company would invest in facilities programs, of something of this magnitude?

Mr. McGARVEY. Sir, from my personal view the direct answer is, I don't think so. I don't believe that industry, if they owned a $7 billion unique physical plant, such as we have, would feel compelled to limit themselves to around $100 million a year investment or about a 1.4 percent investment in that physical plan.

The construction program in NASA since 1978 or 1979 has progressively gone from about $162 million a year down to the $100 million level that you see this year and $98.7 million that is in the fiscal year 1982 budget. We have dropped off very radically within the last 4 years in facility investments.

I personally don't believe that is a wise move, recognizing that there are physical constraints across the board. But with a plant investment of the size that we have, I think we really need to take a hard look at putting a minimum level into that plant to keep it viable and responsive.

Senator SCHMITT. What do you think that minimum is as a percent of investment?

Mr. McGARVEY. Historically, prior to these recent lean years, the NASA budget has averaged about 2 to 4 percent for facilities.

Senator SCHMITT. Do you believe that that maintains a steady state of facility capability, 2 to 4 percent?

Mr. McGARVEY. Yes, sir. I think about 3 percent, which is comparable on the average with industry that is engaged in similar activities, is a reasonable figure.

Senator SCHMITT. So at the present time the NASA plant would be deteriorating at the current level of investment?

Mr. McGARVEY. Yes, sir, if it continues, at the rate we are going now. If you went back and said, "I would accept the fact that 1978–79 was a reasonably adequate program around $160 million," we have failed to even keep pace with inflation alone. If you took a 10 percent per year average in escalation is construction costs over those years, today you would need a program in 1983 of about $259 million to equal what you had in 1978 at $160 million. Or, if you looked at it another way, the program today of $100 million has about 38 percent of the purchasing power in 1978. So, we have gone down at a very drastic rate of decline in facilities investment.

Senator SCHMITT. Senator Riegle, if I may use the interstate analogy, NASA's facilities are becoming one big pot hole.

Senator RIEGLE. I think the whole country is in terms of our bridges and roadways. We are seeing it in Michigan. We are seeing it right here in Washington.

I think that the infrastructure is something that we have lost sight of. I'm concerned about it.

On precisely this point about facilities, would you identify one or two specific facility type needs that perhaps have been pushed to the back burner because of budget pressures that would seem to be the most important items to attend to if we could find the money to do it?

Mr. McGARVEY. Yes, sir. The biggest item, of course, is we have attempted to hold a minimum level in the minor projects. When I say "minor projects," those are ones under $500,000 per project that are in categories such as repair projects, rehabilitation and modification projects, and minor construction. We are pushing a backlog in that category of valid requirements each year of a little over $100 million. We have tried to sustain a level similar to what you see in this program of about $40 million for those types of projects. Doing that alone doesn't give you any opportunity to modernize the plant. You can't include modernization efforts at these low levels.

Senator RIEGLE. Let me focus it for you; the things that were squeezed out. What I would like to know is, give me one or two examples of things that are really compelling needs that we are not getting to at the present time and we are not seeking budgets funds for right now, but if the money were there would be items that you would urge us to allocate resources. What is it that has been pushed off the stove that we need to know about? I would like to have it on the record.

Mr. McGARVEY. A specific project in this year's budget, that we were not able to accommodate in the budget level, was a modification project to the full-scale tunnel or the 30-by-60-foot tunnel at Langley.

Senator SCHMITT. Wind tunnel?

Mr. McGarvey. For $3.4 million. This was a relatively high priority aeronautics item, but it could not be contained in the program at a $100 million level.

Senator Riegle. That is an upgrading, would it not be?

Mr. McGarvey. That is an upgrading of the capabilities of that tunnel, which is well over 40 years old and still heavily utilized in general aviation, and low-speed aerodynamics.

Senator Riegle. If you had extra money right now that would be the first thing you would devote it to, do you think?.

Mr. McGarvey. In our current list of priorities that would have been one of first things we would have picked up.

Senator Riegle. What would be another one or two of that sort that we are not getting to?

Mr. McGarvey. Another modernization effort was a first phase of a small engine components testing facility at the Lewis Research Center for small engines—the size of helicopter engines. Those are the types of facilities. That was $6.9 or $7 million requirement which couldn't be accommodated.

As I had mentioned earlier, one that is in direct support of Ed Smylie's operation was the construction of a frequency standards laboratory at JPL for maintaining hydrogen maser frequency measuring devices. It was a $2.4 million project.

Senator Riegle. Let me ask you this. I have wondered not only as the senior Senator from the State of Michigan, where we have a fair amount of technology activity underway with companies like Bendix and others that are there, but also as the cochairman of the Northeast-Midwest Coalition of 18 States in our part of the country, but thinking specifically of Michigan, I have wondered why it is that Michigan seems not to have become a site for NASA-type activities as such? We have clusters of NASA activities at different places. Obviously, launch requirements, I assume, favor Florida in terms of why that particular facility was established there. But in terms of other facilities that are positioned around the country, apart from that one I have just mentioned, I am wondering why it is that there isn't more of a dispersion of facilities in such a way that more States, more regions would be participating and the effort is more evenly distributed?

Senator Schmitt. Senator Johnson wasn't from Michigan.

Mr. McGarvey. Sir, I really don't know the background, but there has been very little expansion in recent years in NASA. Most of the research centers and the facilities are holdovers from the predecessor organization, NACA, such as in your area or the closest to you is the Lewis Research Center in Cleveland which has been there for a number of years—I am sure, since the early 1940's. The only buildup when the space programs came along was the Johnson Space Center at Houston in the early 1960's and Goddard at Greenbelt, Md. Outside of those centers and using the launch sites, of course, in Florida, there really hasn't been any expansion.

Senator Schmitt. The Redstone Arsenal because of the Army involvement in the V-2 program.

Senator Riegle. I would like to suggest a thought for you, and I also suggest it to the chairman. I remember going through this previously with respect to consolidation efforts within the Carter administration on HUD offices. I remember we ran into this in New Mexico and other places.

I was of the view that we ought to have some divisionalization and, if you will, a sort of regional positioning of facilities so that people had regional access to these facilities. This was also a way for people to feel connected to that work, and in a sense it ties the country together and helps promote national purposes that are truly national in scope.

I think that the NASA program, partly because of its scientific and technical orientation, can tend to become a world unto itself, quite naturally. I think that there would be value in finding ways for NASA to be part and parcel of the lifeblood and economic bloodstream in various parts of the country.

I think it would be healthy, for example, if apart from the facility that you speak about in Cleveland, if in the Midwest, industrial Midwest or Northeast or other regions of the country—even areas that now would seem unlikely places, that it would be healthy to think in terms of over a 10-year period of time, say, to find a way to involve the whole country more fully in NASA work. I think it is good politics. I think it is good creatively.

I know it is not easy to think in terms of expansion at this point because the budget requirements and restraints are as they are, but nevertheless, I think even within budgets there is a way to start thinking in terms of longer range configuration of resources and facilities and work effort in a way that would make NASA more relevant to more parts of the country. I would like to have it be more relevant to my State, but I think that could also be said of many other States.

I would just like to put that thought in your mind, because I think those of us who have a concern and an appreciation for much of what is being worked on here would like to have a way to have it mean more to our constituents aside from occasional space shots, as important and as dramatic as they are, or even the spinoff technology aspects, as important as they are.

I would like to find a way to engrain a working connection on a broader base than we presently have. We also have this problem in the military right now. I tell you quite frankly we are so overloaded with military bases in other parts of the countries, partly because people don't like cold winters. I don't know what we will ever do if we ever have to fight a land war or deploy troops for any period of time in cold places because we're not training people for that function very well. Maybe the thought is that will never happen.

In any event, I think you can get unbalanced to the point where you end up not being able to have the support you need over a period of time that probably is in the national interest. So I just ask you to think about that because sometimes somebody has to set a course. The fact that were are the way we are now, is because somebody way back when basically had a roadmap and we started out that way. But it is up to us now to have today's roadmap in terms of where we are going, where we want to take things.

I think this ought to be a part of the decision process. I think we could do well if we could find a way to fit ourselves more broadly into the country than I think is presently the case.

Mr. McGarvey. Yes, sir. I would only make one comment. We are not large as far as the number of installations. We have nine major centers and a couple of separate operating locations. Those are scattered pretty well across the country. We have installations in California, in Texas, in Alabama, in Florida, in Maryland, and in Ohio.

Senator Riegle. Why don't you just tick off the rest?

Mr. McGarvey. We are not concentrated in one area, is what I'm saying, such as military installations being in the South or in the Southwest.

Senator Schmitt. I think the only one he left out was Virginia. There used to one in Massachusetts, the electronics center; that was transferred to what?

Mr. McGarvey. That was transferred to the Department of Transportation.

Senator Riegle. My point would be that if you take the country and you draw a line across and you divide North from South or you cut it in quarters or cut it in half the other way, East and West, and then you start taking a look, you put your dots on the map, you will find out there isn't much balance there. The Ohio facility, quite frankly, is pretty lean pickings out of the whole thing in terms of regional distribution of all the activity. I think we can do better than that.

The point is that there is a virtue in it. There is a long-term value in it because you are going to find yourself, as this squeeze continues, not having as many friends as you are going to need around here. It is already happening. This guy can tell you about it because he understands it inside and out in terms of what the technological requirements are.

I think this is a real issue. You may or may not think so, but I am suggesting it to you with very serious intent. I think we are going to need to have a different kind of profile 5 and 10 years down the road. Somebody has got to have the vision to think about that and not just tinkering with this project or that project. Somebody has got to think about how you scale this thing if you want to have the kind of broad support that it is going to take to get in there and get a fair share of national resources and commitment.

Senator Schmitt. I think the Senator makes a good point. We will start seeing if we can't in the back of the Administrator's mind and others develop that broad road map and begin to consider how in the expanded agency, which I think we are going to have within a few years, begins to more broadly base its facilities.

The Michigan and surrounding States through the years have been deeply involved in NASA contracting. As you indicated Bendix, I made more flights to Bendix to help them on various systems than sometimes I would like to remember. It was a long arduous trip from Houston, but nevertheless the Bendix folks did an outstanding job in various aspects of the Apollo program and still do contract with NASA.

The auto industry was a major participant in the Apollo program. Chrysler built one of the stages for the Saturn 5, as I recall. I don't know how much of that contracting actually occurred in Michigan, but it did.

But the General is correct. NASA grew out of NACA, and except for the major Texas investment, which was Newland and Goddard investment, which was Newland, they were building on existing facilities. The future though certainly ought to include, I think, a broader distribution, as you indicated.

Senator RIEGLE. I would just make one final point. Our State happens to be very rich in the area of higher education. We have a number of fine public universities and very good higher education infrastructures. I would like to have that infrastructure feel like it is more a part of this area of technological advance. I think there are all kinds of positive feedback both ways.

Senator SCHMITT. You educated most of the astronauts.

Senator RIEGLE. We would like to keep them around. I would like to have them.

Senator SCHMITT. That is the center of excellence that has always been there. I am sure always will be. I heard so much about Michigan State and Michigan while I was in the astronaut program that I got sick and tired of it.

Senator, if you have some more questions, I am going to have to run to another appointment.

General, I appreciate your attention, and if you will answer those questions that we have given you for the record, we would appreciate it.

[The statement follows:]

STATEMENT

OF

BILLIE J. McGARVEY
DIRECTOR OF FACILITIES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY AND SPACE
COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION
UNITED STATES SENATE

Mr. Chairman and Members of the Subcommittee:

I appreciate this opportunity to appear before you today to present the NASA FY 1983 Construction of Facilities Budget request. Our budget request totals $100 million as compared to $104.8 million requested in FY 1982 and $98.7 million that is now available for FY 1982. Although the program is not large, it is a vital program that provides the contractual services for necessary repairs, rehabilitation and modification of existing facilities, construction of new facilities, and the planning and design of facility projects which support the research, development, and testing activities of the Agency.

The NASA physical plant represents capital investments of over $7 billion and a replacement value of more than $20 billion. It is comprised of unique aerospace research, development, test and operational facilities and equipment. Our FY 1983 CoF Budget request has been structured to meet a continuing objective of preserving and enhancing the capabilities and usefulness of this physical plant. The proposed program is a lean but balanced response to requirements which exceed the funding limitations dictated by today's economic environment. The request includes only our highest priority needs. In highlighting the salient features of the budget request, I will briefly discuss several of the large, discrete projects and then summarize the minor program and planning and design activities.

Prior to addressing the details of the budget request, I would like to update you on the status of some selected projects that have been high interest items in prior budgets. The two Large Aeronautical Facility projects costing $85 million each are now nearing completion of construction. The National Transonic Facility (NTF) at the Langley Research Center is approximately 95 percent complete and should be completed in July 1982 leading to full operations by the end of this calendar year. Likewise, the Modifications of the 40x80-Foot Subsonic Wind Tunnel at the Ames Research Center are proceeding satisfactorily. The overall construction is approximately 95 percent complete with the repowering of the 40x80-foot tunnel circuit completed, and the new 80x120-foot test leg addition 90 percent complete at this stage. Construction should be completed in mid-1982 and the facility should become operational in late 1982. Both of these projects have been significant challenges in terms of technical design requirements and construction management, and barring any unforeseen major problems, we anticipate that future updates to you will be in terms of research being accomplished and results achieved.

A second item of continuing interest pertains to the Shuttle launch facilities at the Kennedy Space Center. The facilities supporting the first two launches have performed flawlessly and have suffered very little damage. We are particularly pleased that repair or renovation of launch facilities have not been pacing items affecting turnaround activities between Shuttle flights.

A final update item is the status of our energy conservation program. As you will recall, NASA established a goal of reducing the consumption of utilities energy by 50 percent by FY 1985 as compared to a FY 1973 baseline. This goal has provided the incentive for developing energy retrofit projects and improving facility operations. A 40 percent overall reduction was sustained in FY 1981 despite increased energy needed for Shuttle operations. Our current assessment is that we will probably achieve closer to a 45 percent reduction by FY 1985 than the 50 percent prediction. However, we are continuing to seek further reductions and improvements where feasible.

Space Transportation Systems

We are requesting $23,145,000 for Space Shuttle and Payload Facilities with the major projects located at the Kennedy Space Center (KSC) and the Michoud Assembly Facility (MAF). The Modifications of Solid Rocket Booster (SRB) Refurbishment and Subassembly Facilities at KSC, estimated to cost $1,700,000, are required to support the flight rates projected for FY 1984 and subsequent years. Experience with the first two Shuttle flights and related SRB studies have shown that additional capabilities for refurbishing and assembling forward and aft skirts, frustrums, and nose cones are required. The principal thrust of this project is the relocation of forward assembly buildup areas within the low bay of the Vehicle Assembly Building (VAB), the installation of five new curing booths, and the relocation of small shops from the VAB and from the Hypergol Maintenance Facility.

A second project at KSC, estimated to cost $1,740,000, is for the Rehabilitation and Modification of Facilities for Payload Ground Support Operations. These are required to meet safety standards and codes for the Delta Spin Test Facility (DSTF) and Explosive Safe Area-60 (ESA-60) which are essential spacecraft servicing facilities. Modifications are also required to provide payload-to-user data cabling in the Operations and Checkout (O&C) Building, provide cabling connecting the communication centers on KSC and Cape Canaveral Air Force Station (CCAFS), and to modify the O&C Building to provide a dedicated area for astronaut preflight physiological testing.

The largest Shuttle facility requirement is the Modification of Manufacturing and Final Assembly Facilities for External Tanks (ET) at the Michoud Assembly Facility (MAF) in the amount of $17,845,000. This project continues work funded in FY 1982 and prior years, to provide the capability for the fabrication, assembly, testing and checkout, and application of thermal protection systems (TPS) for External Tanks. Current evaluations based on TPS application experience to date have revealed the need for two additional TPS spray cells for LO_2 tanks and intertanks to achieve necessary increases in production rates. The addition of a new 75-ton bridge crane in the Vertical Assembly Building is also necessary to support future production schedules and eliminate a single point of failure in the manufacturing flow. The Main Manufacturing Plant will be modified to provide a 45-foot clear aisle the full length of the building to alleviate material and component crossflow, backflow congestion, and aisle blockages. Also, the crane system in the LH_2 tank welding area requires upgrading to support increased production rates. TPS closeout operations on external flight hardware attached to the ET in the final horizontal assembly positions require stringent control of temperature, humidity and cleanliness levels to preclude debonding of the insulation. Modifications of these areas are required to provide the necessary controlled environment.

Aeronautics and Space Technology

To enhance the utilization of our unique NASA aeronautical facilities, a total of $24,615,000 is requested for Aeronautics and Space Technology projects. One of the most critical requirements is the need for a consolidated Data Analysis Facility at the Dryden Flight Research Facility (DFRF) estimated to cost $4.5 million. The facility is required to house new computers and ancillary equipment and consolidate the data automation activities at Dryden in an adequate facility. Existing computer equipment is not of sufficient capacity to provide the quality and quantity of flight test data reduction and analysis required to support research and test needs. These computers are being replaced in FY 1983 and FY 1984.

The largest Aeronautics facility project is a proposed $9,000,000 Modification of the Transonic Dynamics Tunnel (TDT) at the Langley Research Center. The TDT is used by both government and industry for research testing to verify flutter and other aerodynamics characteristics of high speed aircraft designs. The TDT's special features include continuous transonic, variable-density flow; a large 16-foot by 16-foot test section; and the flexibility to use either dense Freon-12 gas or air as the test medium. The heavy demand for these capabilities has resulted in a current backlog in excess of 2 years. The major requirement is to improve the capability for scaling the ratio of aircraft mass to air stream density. The proposed modifications will permit increasing the test medium density by 50 percent, thereby, greatly increasing the tunnel's capability for accurate scaled testing of heavy models. The major cost elements are the upgrading of the 20,000 horsepower drive system by 50 percent, providing additional cooling to accommodate the increased tunnel drive power, and modifying power and control systems.

A second wind tunnel project at Langley is the Modifications to the 4x7-Meter Low Speed Tunnel (LST) estimated to cost $7,200,000. A two-year backlog of test requirements for this tunnel also exists despite a two-shift operation since the LST was placed in operation in 1970. These modifications are required to improve the tunnel flow quality and increase productivity. Approximately 20 percent of the tunnel occupancy time is now required for test article installation and calibration. The modifications will include doubling the size of the model preparations area and building new model support carts to ease model preparation and checkout; developing a rotor test area for helicopter models; enlarging the control room, and improving the tunnel circuit flow. These modifications are expected to increase useful test time approximately 17 percent.

Another major Aeronautical test facility project is the Modification of the 450 Pound Per Square Inch (PSI) Air System at the Lewis Research Center estimated to cost $2,920,000. The 450 PSI Air System provides compressed air to the majority of propulsion test facilities at Lewis. The present compressor is over 30 years old, subject to major breakdowns, and must be replaced to provide necessary reliability and continued operations. The old machine will be retained as a backup unit.

The Rocket Engine Test Facility (RETF) at Lewis currently provides for sea-level testing only of low thrust chemical rocket engines. Modification of the facility to provide altitude testing that will simulate the space environment is required. The estimated cost is $995,000. The modifications will provide an altitude exhaust system to permit high altitude simulation. The required work includes the addition of a test engine capsule, diffuser, spray cooler, ejector, and supporting control system.

Other Major Projects

A $2,150,000 Rehabilitation project at the Wallops Flight Center (WFC) is required for resurfacing portions of the airfield runways and taxiways, repairing cracked slabs and surface spalls, and general rehabilitation of the 26-year old airfield pavements. Repairs and resurfacing are needed now to preclude aircraft damages due to engine injestion of pavement debris, prevent further pavement degradation, and reduce airfield maintenance and repair costs. Keeping the Wallops airfield in a serviceable condition is essential for current and future aeronautical research activities.

Minor Facility Projects

Completing this FY 1983 CoF Budget request is $39 million for Repair, Rehabilitation and Modifications, and Minor Construction, and $8.25 million for Facility Planning and Design.

Repair of Facilities, not in excess of $500,000 per project, totals $15 million. The Repair Program is designed to provide a means of restoring our facilities to their originally intended and designed capability. These projects were distilled from over $25 million of priority items.

$20 million is requested for Rehabilitation and Modification Projects under $500,000 per project. The purpose of this program is to protect, preserve and enhance the capabilities of facilities so that they can accomplish the intended mission in a more efficient, safe, and economical manner. These projects are high priority items selected from total requests exceeding $33 million.

The third element of the Minor Program are the Minor Construction Projects not in excess of $250,000 each. These projects total $4 million and consist of new construction and additions to improve the usefulness of NASA's physical plant in response to changes in utilization and adaptations required by changes in technology or mission needs.

Finally, we are requesting $8.25 million to conduct the necessary advanced planning and design. Typical of the activities financed by this element of the budget request are preliminary engineering reports, cost estimating, scheduling, final design, site investigations, engineering studies, and installation master planning.

Summary

In summary, this $100 million budget request for NASA facilities work in FY 1983 is a very lean program, which addresses our most urgent facility requirements for carrying out the principal research, development, and testing activities and provides for the most essential repair and rehabilitation needs. We sincerely appreciate your support of our facility programs in the past and request your favorable consideration of the FY 1983 CoF budget.

Senator SCHMITT. The hearing is recessed until Thursday when we will have a closed hearing following the testimony on international programs. We will have a closed hearing with the Department of Defense and NASA representatives.

[Whereupon, at 12:05 p.m., the subcommittee adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1983

THURSDAY, MARCH 18, 1982

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The committee met, pursuant to notice, at 9:30 a.m., in room 6226, Dirksen Senate Office Building, Hon. Harrison Schmitt (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR SCHMITT

Senator SCHMITT. The hearing will come to order.

This morning we will have a two-part hearing. A little after 10 we will briefly recess so that the room can be cleared for the purposes of receiving classified testimony from the Department of Defense. First this morning, however, we will hear from Kenneth F. Pedersen, Director of International Affairs for the National Aeronautics and Space Administration.

The NASA image internationally has suffered somewhat over the past year or two as a result of unfortunate and at times seemingly uncoordinated decisions on the budget that involve our friends and partners abroad. I hope that we will hear today that the damage is being repaired and that our allies once again think we are a trustworthy partner in international space activities.

Mr. Pedersen, if you would summarize your testimony as appropriate and then we will have a few questions for you.

STATEMENT OF KENNETH S. PEDERSEN, DIRECTOR, INTERNATIONAL AFFAIRS DIVISION, NASA, ACCOMPANIED BY JAMES MORRISON, DEPUTY DIRECTOR

Mr. PEDERSEN. Thank you, Mr. Chairman. It is a pleasure to testify on NASA's international space activities. With your permission, Senator, I would like to summarize my statement and submit the full statement for the record.

I am pleased to report to you that NASA's fiscal year 1983 budget request provides continued strong support for NASA's international programs. Of great significance to the international community of future Shuttle users, is that this budget request moves the Shuttle program out of the development and test phase and into the initial operational stage. This budget request also continues procurement of the second European Space Agency [ESA] Spacelab unit and additional remote manipulator system [RMS] hardware from Canada to outfit the currently planned Shuttle fleet.

A 1985 launch of Space Telescope is supported by this budget. This is an event eagerly awaited by the worldwide scientific community. The budget request also supports a 1985 launch of the Galileo mission to Jupiter, a mission in which Germany is an active cooperative partner.

I might note, Senator Schmitt, as you and other members of the subcommittee recall, budget constraints last year required NASA to eliminate the U.S. spacecraft from the international solar polar mission, a joint mission with ESA. While I do not want to underemphasize the distress this action caused both sides, I believe that both NASA and ESA are determined to maintain and to further good cooperative relations. Both the Administrator of NASA and the Director General of ESA have recently confirmed their commitment to the principle of continued cooperation between the United States and Europe in space activities. I am pleased to tell the subcommittee that this budget request permits NASA to meet the U.S. international solar polar mission [ISPM] obligation to provide launch services, tracking and data acquisition support, the RTG power supply and support for the U.S. experiments that will be flown on the single European spacecraft.

Senator SCHMITT. If I may interrupt, you have not told me why, if I were a European, I would continue to do that.

Mr. PEDERSEN. I believe, based on the discussions we have had, not only within NASA but with other portions of the executive branch, that there is a very strong commitment throughout the executive branch to honor the remainder of our obligation.

Senator SCHMITT. Why now, when there was no commitment a year ago?

Mr. PEDERSEN. Senator, I think that all of us learned something from the ISPM. I do not think there is anyone who would say that there were not some mistakes made in how that issue was handled. I think we have learned something; and we are going to make an extended effort to maintain that commitment.

Senator SCHMITT. Why is that a lesson that NASA, in business now for over two decades, should have to learn? Why is that something we should have to learn?

Mr. PEDERSEN. Senator, I might point out that it is precisely because, for over two decades, we have never had to withdraw from any significant international agreement that, I think, came as a learning experience to us, precisely because we had never experienced it before. It was a difficult experience.

Senator SCHMITT. That is like practicing starving to death. Why do you have to do that?

Mr. PEDERSEN. The budget reductions were such, as I testified to you last year, that it was a case where we had to do something. I would only reemphasize that we are the victim of our own success to a certain extent. In all of NASA's major programs that have international involvement, any cut has international impact.

Senator SCHMITT. What we are a victim of is NASA carrying the development of major new flight hardware solely on its shoulders, at the expense of other mandated activities of the Space Act, including international activities. That is what we are a victim of.

If there is a lesson learned, it is that the administration does not yet understand what the mandates of the Space Act are. It is not your fault, but it is, I think, a terribly black mark on what otherwise has been an exemplary international record for NASA. Frankly, if ESA decides not to trust us I do not blame them.

I do not think that in 1 year and with one set of meetings or even six sets of meetings, you are going to see the Europeans fully trust the commitment of this country to international missions. It is unfortunate, but I think that is the reality.

Mr. PEDERSEN. Senator, perhaps I can convince you that there is a basis for that continuing trust. I would hate to think that one event would necessarily undercut 20 years of cooperative activities.

Senator SCHMITT. But unfortunately, it is an event in the context, again, of severe cutbacks in major portions of NASA's mandated Space Act missions, including international missions. If it were not part of a pattern your argument might hold water, but it is part of a pattern of withdrawal from other responsibilities that NASA has under the Space Act, including international responsibilities.

Please proceed.

Mr. PEDERSEN. Thank you.

The fiscal year 1983 budget request also supports the continued development of the Gamma Ray Observatory GRO, in which Germany and the Netherlands are participating in the instrument development along with the United Kingdom, an active Spacelab utilization program; and a 15-month demonstration phase of the satellite-aided search and rescue SARSAT program which is a joint program between ourselves, Canada, and France with the Soviet Union also a cooperating partner in that overall program. NASA's geodynamics program continues to exhibit strong international interest and involvement.

As you can see from the above discussion, this budget request continues most of the currently planned space science and applications missions that involve international participation. I would like to say something, however, about competition. It certainly is no secret that in recent years we have seen a measurable growth in foreign space budgets and capabilities. This growth has raised concerns about increasing foreign competitiveness with the United States, both in terms of technology and in the space hardware market. I would like to briefly address these very real concerns.

Many foreign space budgets rose steadily throughout the 1970's, although there has been some leveling off recently as other countries have experienced many of the same fiscal restraints to which this country has been subjected. However, the budgets have been maintained at fairly high levels compared to the past. Furthermore, recent foreign budgets have shown an increased emphasis in areas of potential commercial payoff, such as communications, remote sensing and launch vehicle development.

The members of this subcommittee are familiar with many examples of this foreign challenge and I will not do more than list a few items today. ESA has successfully completed the testing of its Ariane launch vehicle and the first operational flight is now scheduled for this summer. ESA recently approved funding to further upgrade of the Ariane vehicle with plans to develop and test the Ariane scheduled for some time in late 1985.

Several countries, notably France and Japan, are developing land and ocean remote sensing satellites. Communications satellites are being developed and sold by a number of foreign firms, and both ESA and Japan are doing experimental work in the potentially commercially important 30/20 gigahertz band. This competition should come as no surprise. The potential market for space hardware and services is large and it is technically challenging. Indeed, in my opinion it would be surprising if U.S. leadership in this area were not challenged.

What is of concern, however, is the evidence we see that foreign governments are adopting sophisticated strategies to enhance and aid their aerospace industries' competitive positions. Some foreign governments support their space industry not only through R. & D. funding, but also by price subsidies and financing assistance, development of attractive package deals, and creation of quasi-governmental marketing organizations. We know that the Europeans, for example, have established Arianespace, a semiprivate corporation with extensive French Government involvement, to market Ariane launch services. Arianespace has contracted with Grumman Corp. in the United States to be its marketing agent. Similarly, France has created a largely Government-owned corporation called SPOT-Image to market the data products produced by its land remote sensing satellite, SPOT is now scheduled for launch in 1984 or 1985. In addition to the marketing of SPOT data, SPOT-Image will promote the sale of related French commercial equipment and services and, like Arianespace, SPOT-Image will establish a U.S. subsidiary to establish business here.

I am confident that U.S. industry can meet the competitive challenge to its leadership. To help industry meet this challenge, NASA's budget request contains support for research and technology in the fields of remote sensing, space launch vehicles, and other program areas. In the area of launch services, NASA is aggressively pursuing improvement programs to lower production and operating costs and to facilitate user relationships.

Senator SCHMITT. If I could interrupt, I would ask you for the record to present us with a more realistic assessment than that paragraph provides. Now, this is a friendly committee. You have a lot of friends in the Congress and you do not have to blow smoke at us about how we are to meet the competitive—how we are moving to meet the competitive challenge.

We are not, and we all know that. We are all grown up. We know we are not meeting the competitive challenge of the French in communications satellites, in their remote sensing, particularly stereo image technology. We are just not doing it.

To say that industry can meet the competitive challenge is true, but unfortunately the environment in which industry must operate is not conducive to actually meeting that challenge. That paragraph just does not wash.

Mr. PEDERSEN. Senator, I cannot dispute the seriousness of the challenge and the situation. I would say, however, that in recent situations where international communication satellite bids were offered, in Australia and Indonesia and elsewhere, U.S. firms have done extremely well, and they continue to do well in the Intelsat area.

I think the challenge is real. We are losing sales to competitive firms abroad. But the record indicates that we are still doing a good competitive job. I think the question is: What must we do to maintain that?

Senator **Schmitt**. Well, the record also indicates the trends are in the wrong direction.

We are not maintaining it. We are going downhill in those markets. They are being targeted by aggressive, well-thought-out, excellent financial term proposals on the part of the French, and the Japanese are moving into the field. We are just not meeting the challenge. We are capable of meeting it, but we are not.

And I hope you will try to give us a little bit more realistic assessment of that situation and the trends and NASA's judgment on what must be done in and out of NASA in order to reverse those trends.

Mr. **Pedersen**. I would be happy to expand on that, Senator.

Senator **Schmitt**. And I think it would be appropriate, staff reminds me, to include in that the aeronautics side of things, which certainly included the French, the Europeans, and Brazilians and other nations are in fact beating the pants off us by the type of airplanes they are producing, as well as their marketing system.

Mr. **Pedersen**. We will supply you more information on that, sir.

[The following information was subsequently received for the record:]

U.S. industrial firms are facing increased foreign competition in high technology areas from a number of foreign countries, all of which are our allies. This is due in large part to the fact that there have been macroeconomic changes in the way the world does business, particularly charcterized over the past decade by growing pressure from the Third World in traditional market areas such as textiles and steel. As a result, our allies are turning to high technology areas in order to survive economically. This puts them in direct competition with us for traditionally "American" (high technology) markets. This relatively recent phenomenon places before us two challenges: (1) make our own high technology industries more efficient to meet the new foreign competition; and (2) expand the market for high technology products so that both we and our allies can survive economically. We could take a totally "them-*or*-us" perspective, however, if we are to be leaders of the Western Alliance we must take a "them-*and*-us" strategy, which is more difficult.

In the launch services field, European salesmen are moving aggressively into a traditional U.S. preserve by providing reimbursable launch services. The European launcher, Ariane, with its aggressive marketing, low prices, and attractive financing will be able to capture a meaningful share of the world market for reimbursable satellite launches.

In remote sensing, there is a rapidly growing competition to the United States. France and Japan have been motivated by the prospect of worldwide commercial sales to benefit their industries. Some developing countries, including India and Brazil, are motivated by the political prestige of operating their own systems. Furthermore, aggressive foreign competition has developed for ground station hardware. For example, Canadian, German, French and Japanese firms have well-developed lines of ground receiving hardware and processing equipment. Non-U.S. firms have even acquired a significant portion of the market for supplying ground station equipment to countries receiving Landsat data by direct readout. In addition, a number of foreign firms also offer data analysis and other value-added services, an area which, until recently, was dominated by the United States.

In the area of telecommunications, the ability of the U.S. industry to continue to dominate the domestic and international telecommunications services market depends on its ability to be fully competitive. This includes competition in new technology areas such as the 30/20 GHz frequency bands where the Europeans and Japanese are ahead of us in their development programs. The real question for the

United States in this and other areas is not whether we should be actively developing these technologies, but whether the principal role in this development should be taken by the public or private sector. European and Japanese firms are also now serving the worldwide market for telecommunications equipment. In some European countries, government-industry teams and direct government-sponsored R&D serve to reduce perceived program risks and spur domestic industry, thus allowing effective international competition.

However, despite the growing capabilities abroad, the United States remains a strong competitor in space communications. For example, over the past year, U.S. companies have done well where they have chosen to bid in major communications projects, because the United States still has the most advanced technology available, and U.S. industry has demonstrated the capability to handle large contracts as well as a good track record.

The problem for the U.S. Government in general, and NASA in particular, is that, in today's economy, we cannot do everything, so we must make choices on where to concentrate our recources. NASA's foremost priority is establishing an operational national space transportation system. While the FY 1983 budget request marks the end of the Shuttle development and test phase and the beginning of the initial operational phase, NASA plans to continue a vigorous program to lower production and operations costs, and is actively developing improved strategies for working with users. Attention also needs to be paid to maintaining the capability to handle the demand for space launching services. The proper role of the U.S. Government in cooperation with private industry in this activity is not clear, however.

NASA has a balanced R&D program which extends beyond the space transportation system. For example, in the remote sensing area, NASA is well aware of the increasing competition from foreign nations. NASA's R&D program involves improved sensor capabilities that will exceed those sensor systems being developed by Europe and Japan. This NASA technology development, called the multi-linear array program, includes development of short-wave infrared detectors, multispectral charge-coupled devices, and a novel imaging-spectrometer concept. The foreign competition is, however, ahead of us in two aspects of remote sensing development: (1) a commitment to a continuing civil space remote sensing program, and (2) national agreement on an organization to carry out such a commitment. These factors indicate that, to be competitive, more than just technology is needed. In addition, the U.S. Government is currently examining the role it should play in telecommunications R&D.

It is my belief that the U.S. Government efforts should complement strong private sector R&D activities and aggressive marketing strategies. This is particularly important because, in addition to the trend of foreign governments' funding R&D in commercially important areas, they are also adopting sophisticated strategies to help their industries compete (price subsidization and financing assistance, development of attractive package deals, and creation of quasi-governmental marketing organizations). The Administration is aware of these activities and is currently studying what it can do to assist U.S. industry to compete, such as providing assurance that U.S. firms are not victims of unfair competitive practices.

In aeronautics, manufacturers in European and other countries have, in recent years, made significant gains in markets which previously were largely dominated by U.S. companies. The European Airbus has overtaken Douglas and Lockheed in widebody transport orders and now ranks second only to Boeing. French, Italian, and German companies have captured significant portions of the world helicopter market. In general aviation products, many of the executive transports and virtually all of the new larger commuter aircraft now being sold in the United States are of foreign manufacture. As a result, for the first time, the value of general aviation imports in 1981 exceeded the value of exports. Foreign subcontractors produce large components of U.S. transport aircraft—in some instances, components requiring advanced technology and sophisticated manufacturing techniques. In fact, U.S. companies contemplating new large developments now appear, almost automatically, to consider some form of partnership with foreign companies.

U.S. companies still enjoy a very healthy share of the world's business in aeronautical products, including major subsystems in foreign aircraft programs. Some of the recent foreign gains can be attributed simply to foreign concentration on market segments now being pursued aggressively by U.S. manufacturers. Foreign government policies favoring public support or ownership of manufacturing industries have been another factor. "Buy local" pressures have increased in several countries, or communities of countries, in which growing markets now provide stronger leverage for participation by domestic industries. In addition to the market penetration aspect, U.S. companies have also sought foreign partners to reduce the burden and the risk of the extremely high investments associated with aircraft development.

Thus, technology is not the only key to success in international competition. It is, however, a vital element. U.S. civil and military aeronautical products are technologically equal or superior to any in the world, and that technology is based on research conducted over many years—in some instances, for as much as 20 years before incorporation in development. In order to counter the serious market penetration trends posed by foreign competition, it is essential for the U.S. aerospace industry to improve its marketing approach and financial arrangements in domestic and international sales markets as well as to sustain its high productivity and technology advantages, thus resulting in the most attractive offerings to potential buyers.

It would be unfortunate, if the focus on competition were allowed to divert our attention from those areas where international cooperation offers significant benefits. No single nation can fully pursue all fields in science and technology, particularly during this period of worldwide fiscal restraint. I think that we can demonstrate that cooperation has produced for NASA and for this country a large number of significant benefits. To reap the benefits of cooperation without jeopardizing the competitive position of U.S. industry, care must be exercised in selecting, defining, and implementing joint programs. Projects leading to the early development of commercially useful technology are not usually open for international participation. In projects where there is foreign involvement, that involvement is structured so as to avoid technology transfer.

Generally, foreign participants undertake to provide a discrete piece of the overall project and are then responsible for developing the resulting technology and hardware. Only the minimum amount of technical information necessary to insure effective interface among the various elements of a project is exchanged. Although we have heard concerns expressed about technology transfer, I believe that the facts support my claim that very little significant technology escapes the United States as the result of NASA's cooperative programs. It is important to note that cooperation can also be a factor in reducing competitive challenges and maintaining U.S. leadership. Cooperative programs frequently link foreign space objectives to our own, for example, when other countries develop Shuttle-compatible systems.

As times change, it is imperative that we constantly evaluate our methods. I anticipate that NASA will need to entertain new modes of cooperation with foreign space agencies in the coming years. For example, NASA has traditionally funded the major share of cooperative projects, with foreign partners playing for a minor role with regard to total mission costs. However, ambitious foreign space budgets and increased capabilities abroad mean that we no longer need to play that role in all cases. In fact, foreign partners are taking larger roles in several recent missions we have agreed to jointly undertake. Moreover, NASA can now for the first time contemplate cooperative ventures where we are not even the primary actor. We are discussing, for example, with Germany the possibility of participating in their Rosat mission planned for 1986. I would not want to rule out U.S. instruments flying on missions where foreign partners provide the spacecraft, the launch and even the tracking and data acquisition. In fact, we are currently discussing the possibilities for such missions with several prospective partners.

Finally, Mr. Chairman, I would like to briefly mention NASA's involvement in the upcoming Unispace 82 Conference. NASA is participating actively in interagency preparations for Unispace 82 to be held in August in Vienna. Unispace 82 will focus on the practical benefits to be gained from space science and technology activities, in particular how these benefits can be realized by the developing countries. There are already significant U.S. efforts underway in response to the desire of developing countries to increase their involvement in space activities, and the United States will emphasize these efforts at the conference. Unispace 82 will also offer countries the opportunity to learn about other aspects of the U.S. civil space program which could be useful in social and economic development.

Mr. Chairman, I would like to end there, except to indicate that I have with me today at the table Mr. James Morrison, the Deputy Director of the International Affairs Office, who has been playing a day-to-day role in our Unispace planning.

I would be happy to answer any questions you might have.

Senator SCHMITT. Thank you, Mr. Pedersen.

In your statement you say that "over 50 percent of all civil payloads already booked to be flown on a Shuttle are foreign, and NASA is currently talking seriously to a number of other countries on possible future Shuttle use." With only four orbiters in the plan and no funding in this year's budget for a fifth orbiter, the U.S. commercial missions, NASA missions, DOD missions also on the books, is it your view that we are going to meet Shuttle demand with the fleet and plans presently in place?

If not, could you describe your scenario of what you see happening?

Mr. PEDERSEN. Senator, I think it is going to be very tight with a four-orbiter fleet.

Senator SCHMITT. It is my understanding we are already turning away users in the 1985-86 timeframe.

Mr. PEDERSEN. We are certainly, not actively, turning away users. We are having to make very careful assessments about how the demand will be accommodated in trading off between the Shuttle and expendable launch vehicles. It is correct that our manifest is quite full, that the demand for additional international launches is there, and that we are actively talking to additional partners. It is going to be a very tight fit and quite a challenge. We are, of course, having to make some assumptions about how many of those missions will fly in the timeframes they are now estimating which allows some flexibility. But, I do not want to underestimate the tightness of the situation.

Senator SCHMITT. And it would only get tighter if certain defense requirements began to preempt payload space.

Mr. PEDERSEN. Yes; except, Senator, the administration with NASA is undertaking several mixed fleet studies to look at the various concepts and mixes by which this demand can be met. Those studies are still ongoing, and I think that the effort assumes, and the intention is, that we will go after all of the international business we can get. We fully intend to have the launch capability there.

Senator SCHMITT. Well, that is very nice to say, except that when you look at the rate of flights and you look at the facility bottlenecks that exist and prohibit increasing that rate, and when you look at the potential for displacement of nondefense payloads by defense payloads, you are really saturated right now. Is it not logical to assume that we are going to have to turn away flights in the future?

Mr. PEDERSEN. We are just beginning to discuss the 1986 through 1988 timeframe with the customers. At this point, we do not have the same situation that we have in the 1984-85 time period. I would hope that we would not reach a position where we would have to turn away customers, so to speak.

Senator SCHMITT. Well, what are other countries indicating? Do they believe the Shuttle is going to be available for their payloads in that mideighties timeframe, or are they starting to look, for that reason, very seriously at alternative booster systems?

Mr. PEDERSEN. In some cases, there is an amount of what we call double and even triple booking, where they will book on Shuttle, book on one of our ELV's, as well as book on Ariane. Realistically, this does represent some hedging of their bets, some concern about whether our system, or, indeed, perhaps even the Ariane system, will be able to provide the services necessary. However, the majority of the international customers that I have talked to are reasonably confident that we will meet our commitments in the launch area. I am hopeful we can do that.

Senator SCHMITT. Now, tell me, have we turned away any customers in the 1985-87 timeframe?

Mr. PEDERSEN. I am not aware, Senator, of any customer that we have turned away. We have told some customers that we would not be able to assure them that they would be on the Shuttle and that we might perhaps have to launch them on an ELV or a mix, if more than one satellite is involved, which in every case that I'm aware of, has been acceptable to the customer. I am not aware of any customer that we have turned away, no, sir.

Senator SCHMITT. Will you check your records and provide us any alteration of that statement that might be necessary?

Mr. PEDERSEN. I would be happy to do that.

[The following information was subsequently received for the record:]

To date, NASA has never been unable to provide launch services on request. On several occasions, however, there have not been openings on the Shuttle manifest at or near the customer's desired launch date. Some of these customers have, however, booked Shuttle launches regardless. Other customers have scheduled their launch on an expendable launch vehicle in order to obtain launch services when they want them. There is always considerable flux in user plans between initial launch scheduling and the actual launch date. NASA's manifesting procedures do permit us to make adjustments in an equitable manner as these shifts occur. Thus, customers whose initial launch dates were far later then they desired have been moved up to dates closer to their needs, while others have moved from the Expendable Launch Vehicle manifest to the Shuttle manifest. We are not, however, aware of any launch customer who has elected to fly on Ariane solely because of schedule considerations. Our experience in satisfying user needs has been quite good.

Senator SCHMITT. Has the head of the U.S. delegation to Unispace 1982 been officially appointed yet?

Mr. PEDERSEN. No, sir.

Senator SCHMITT. When do you expect that to happen?

Mr. PEDERSEN. I would certainly hope as soon as possible.

Senator SCHMITT. Are we proceeding with our preparations?

Mr. PEDERSEN. Yes; very actively so.

Senator SCHMITT. What would be your assessment of the status of these preparations?

Mr. PEDERSEN. I think it is going to be like our launch manifest—very tight. We started late, Senator, for some good foreign policy reasons.

Senator SCHMITT. That is your assessment, not this committee's.

Mr. PEDERSEN. At this point, we are on a very, very fast track. We have developed and reviewed the draft conference report that the U.N. has produced. State Department representatives and I will be in New York next week and the following week to attend the Committee for Peaceful Uses of Outer Space meeting to go over that draft report. We have developed a number of concerns about that report which we will attempt to influence the committee on during this period. We have held extensive meetings with industrial representatives to assess their interest in participating in the exhibition associated with the conference. We have begun to try to develop some U.S. initiatives that we might be in a position to present at the conference.

We have submitted a national paper to the U.N., and I am confident that all of this can and will come together in time, Senator. But, it is taking a great deal of effort. I am happy to say that various agencies are doing an excellent job. The State Department has now appointed a full-time U.N. coordinator, Jerry Helman, who is now onboard. Therefore we anticipate that this will significantly help the situation.

Senator SCHMITT. I am going to interrupt the testimony right now to let everybody know who is here that NASA is momentarily going to announce that the third development flight of the Space Shuttle will proceed on schedule and will plan to use the White Sands Northrop landing site as their primary recovery site.

I think that is an extremely important decision. It shows that we are maturing the system very, very well, that there is confidence that we can land at a variety of locations, and that this very important, essentially mid-continent landing site is important for many reasons, including some future national security potential activities, that we will have a tested landing area in which to land.

It really is important that NASA show this kind of maturity at this stage, I think, that we are not wedded to one particular landing site and that we can in fact use a variety of sites in this country.

The U.S. national paper for Unispace 1982, is that in draft form now?

Mr. PEDERSEN. I believe that is in final form and has been forwarded to the U.N. You have copies, Senator.

Senator SCHMITT. In your judgment, how does our effort compare to that of the Soviet Union for Unispace?

Mr. PEDERSEN. I think the Soviets are going to make a major effort at Unispace, both politically in terms of the substantive debates within the conference and, perhaps of equal importance, in terms of their exhibition to attempt to demonstrate in a very visible way the scope and breadth of their program. We have signs, for example, that this is the case. They have reserved a large space in the exhibition hall. We have heard that they are sending an impressive array of space hardware to be demonstrated. We have also been informed that they will have a fairly large contingent of cosmonauts there. The signs are that they are taking this conferences quite seriously.

Senator SCHMITT. Much more so than we are, I presume.

Mr. PEDERSEN. I certainly wouldn't want to say that. The Soviets have historically placed at various shows and conferences such as the Paris Air Show, a great deal of emphasis on the visible outward manifestations of their program.

Senator SCHMITT. Do you think that is misplaced?

Mr. PEDERSEN. No, I do not nor do I think that we are going to be embarrassed in any way there. I am confident from our discussions with U.S. industry that we are going to mount an equally impressive exhibition, that we have no reason to be embarrassed about our leadership in space and our accomplishments, and that the people who come to Unispace 1982 will not find that the United States is in any way second rate in how we prepare for and present ourselves at the conference.

Senator SCHMITT. Have the Soviets prepared a basic paper for presentation at the conference?

Mr. PEDERSEN. They have prepared a national paper. It is an excellent job, as best I can identify. It is one of the most thorough unclassified descriptions of their program that I have ever seen. Quite frankly, it is an excellent paper, particularly because it is unclassified and is, therefore, available to a large audience.

That is another sign, I might say, Senator, of the seriousness in which they are taking this conference.

Senator SCHMITT. What are the major areas that we are emphasizing in our paper?

Mr. PEDERSEN. We are emphasizing several areas. We are emphasizing our space science program, particularly as it relates to our accomplishments and as it relates to the foreign involvement in our space science program—the openness of our program and our extremely attractive track record in terms of international participation and benefits in terms of data sharing and so on.

Senator SCHMITT. But the future space science program concentrates on what—Galileo and large space telescopes?

Mr. PEDERSEN. That, but also on Spacelab where we have a number of foreign investigators flying, as well as our explorers and X-ray astronomy satellites which are of great interest around the world scientifically. The primary emphasis, I would say that the primary emphasis is on the applications area, particularly because the emphasis of this conference for the developing countries is emphasis on our work in the remote sensing area, the work we have done in photovoltaics, the work we have done with communication satellites, and the work through the AID program. We have tried to focus on the ways in which our program has offered tangible benefits to not only developed but developing countries.

Senator SCHMITT. But the Soviets' presentation relative to the future presumably has considerably more opportunity than ours for international cooperation.

Mr. PEDERSEN. I certainly would not say that. The Soviet Union has used international cooperation quite selectively and frequently in a highly political manner. For example, they will be flying a French cosmonaut later this year. In addition, they have just indicated that two Indian cosmonauts are going into training. There are some French instruments on their Venera-Halley mission, but they have by no means, not just in terms of the openness of their program, shown the willingness to take scientific applications partners. We know very little, for example, about their remote sensing program. They do not share the data in the way we share our data internationally.

Senator SCHMITT. Don't you think their use of their space activities as an instrument of their foreign policy is significantly superior to ours?

Mr. PEDERSEN. They use it in a different way. We can quibble about whether different is better. They certainly use it in a different way. They use it in a highly visible manner as a major arm of their foreign policy.

Senator SCHMITT. Why shouldn't we be doing the same thing. honestly and straightforwardly? Why shouldn't we be doing the same thing?

Mr. PEDERSEN. I think we are in some ways. We have taken three Europeans into training. We are, I think, doing a better job perhaps than we might have in the past in terms of recognizing the importance of space to our foreign policy efforts. I think our preparations for Unispace reflect that. The question about whether we ought to use the Shuttle in a more visible political way is one that is interesting and is one, which I think, we ought to review again.

Senator SCHMITT. I really don't think you want to say that our preparations for Unispace reflect any new and great understanding of the foreign policy implications of space. We do not even have a head of the delegation. It has only been in the last few weeks that we even decided to participate.

There has been, up until now, no obvious high level administration recognition of just what Unispace is all about and what the implications of it are. It is comparable to our lack of understanding of the implications of what goes on in the ITU and in the international communications conferences. It is not confined to this administration. It is generic within the State Department and other branches of the U.S. Government.

I do not think we have anything to crow about in terms of our recognition of the international aspects of space. Fortunately, we are an open society and everybody knows what we are doing. We get a lot of free press as a consequence, but in terms of understanding what space means to the future of this planet, I would not say that the State Department has very much comprehension of that role.

Mr. PEDERSEN. Let me say, Senator, that I believe—and this is obviously somewhat self-serving and obviously somewhat parochial—that NASA's international space programs are excellent.

Senator SCHMITT. I recognize that and I am sorry to interrupt, but it is not NASA that I am concerned about.

Mr. PEDERSEN. I think our program is a superb program. I will not quarrel with your statement that we need to call more attention to the achievements, to the openness and to the objectives of our program around the world.

Senator SCHMITT. What is the status of the second draft of the Unispace conference report?

Mr. PEDERSEN. That second draft is currently under review. It is the draft that will be discussed beginning next week in New York. By that time, we will be in a position to make our comments on the report. Then, the second draft will be turned into a third draft which, for all intents and purposes, Senator, will become the working report for the conference.

Senator SCHMITT. When do you think we will be able to see the second draft?

Mr. PEDERSEN. I was under the impression that copies of that second draft had been made available. If they have not been, you can see them immediately. We have just received them ourselves within the last week; but, if I am mistaken and the staff has not received them, I will be more than happy to make them available.

Senator SCHMITT. For our record, would you give us an indication of the specific commitments we have from industry for the Unispace exhibits? What are some of the significant features of those exhibits and how do you believe they compare with those of other active space nations?

Mr. PEDERSEN. Yes; we will supply that for the record.

Senator SCHMITT. And also, maybe for the record, we would like to have your assessment of how those countries and any others are proceeding in their preparations for the conference.

Mr. PEDERSEN. We will be glad to supply that. I think we will have a much better understanding of that following the outer space meeting in New York.

[The following information was subsequently received for the record:]

As of March 24, four Unispace exhibit commitments were received from the following companies: McDonald Douglas, Ford Aerospace, Rockwell International and Hughes. Three other companies, RCA, Scientific Atlanta and AT&T have indicated interest, but want more details before making a commitment. The scope and major feature of the different countries' exhibits have not yet been firmly defined. We do know, however, the general plans of many countries. For example, the Soviet Union, ESA, India, Indonesia, Intelsat and Inmarsat are all planning to conduct demonstrations of space technology in areas including remote sensing, meteorology, communications and processing of Landsat data. Several countries including Japan, India, the U.S.S.R., Canada, ESA and the U.S. will hold technological exhibitions on the peaceful uses of outer space.

Arrangements have been made with the American Institute of Aeronautics and Astronautics (AIAA) to manage the U.S. exhibit at Unispace 1982. AIAA is in the process of soliciting participation from private industry, making initial contacts by telephone, and following-up with letters. Twenty-seven letters have been sent by Federal Express to the Chief Executive Officers of major corporations, forwarding detailed information on costs, floor plans, time constraints, etc. Response to these letters are expected very soon.

In addition, NASA has provided a list of small businesses to AIAA to be contacted during the week of March 22. Some of these firms have been contacted, but have not made a commitment yet.

As part of the preparation for Unispace 82, over fifty U.N. member states, including the United States, have submitted national papers for the conference. In addition, India, the European Space Agency, Japan, Indonesia, and the Soviet Union will be holding month-long exhibitions in the lobby of the U.N. General Assembly Building in the months prior to the Conference. To assist developing countries in preparing for Unispace 82, the U.N. is holding regional seminars on application of remote sensing and satellite communications. ESA, Intelsat, Intersputnik, ITU, the

U.S.S.R., Japan and the United States have sent experts to these seminars to provide lectures on the state-of-the-art and to guide discussions. In addition, the United States as well as other countries, is examining possible initiatives that could be proposed at Unispace 82.

Senator SCHMITT. Is NASA trying to cover the country's rear on the political and legal aspects that will be covered at Unispace, recognizing your principal responsibility on the more technical aspects?

Mr. PEDERSEN. I think there is very little doubt, Senator, that although the conference is primarily billed as, and hopefully will be, a technical conference, that political and legal issues will intrude themselves. It is sometimes hard to make the distinction where one begins and the other ends. We have gone through the report paying special attention to those issues and special attention to the U.S. interest in those issues. I am hopeful that we will be able to not only protect the U.S. interests but to make some productive contributions to the resolution or forwarding of these issues.

Senator SCHMITT. Do we have an official position yet on the proposed United Nations Center for Outer Space?

Mr. PEDERSEN. Not an official position yet. We have reviewed it, and the position policy draft papers have been prepared. Although, we are not required to have such a position during the period we are in New York, I believe it would be very useful. My intent would be that by the end of this week or certainly after some discussions in New York with other interested delegations that we will have a position on that.

It is an interesting proposal, Senator, and we need to give it careful consideration; but, it is the sort of thing that requires a lot of interagency involvement.

Senator SCHMITT. Are you studying any counterproposals, alternatives?

Mr. PEDERSEN. To the center?

Senator SCHMITT. Yes.

Mr. PEDERSEN. We are looking at alternatives but I don't know at this point that we have any that I would particularly represent as counterproposals as such. This is not a new proposal, Senator. It has been around for several years.

Senator SCHMITT. Well, I hope you will keep the subcommittee informed on the U.S. position and proposals relative to that center.

Would you say that the Arianespace is comparable to the U.S. creation of Comsat?

Mr. PEDERSEN. I am not an expert on the history of Comsat.

Senator SCHMITT. Maybe we will let you supply some comparative information for the record.

[The following information was subsequently received for the record:]

COMSAT was the institutional result of an intense debate among the Executive and Legislative Branches and the private sector (chiefly the international record carriers and the aerospace industry) as to how the United States should implement commercial satellite communications. According to the legislative history of the Communications Satellite Act of 1962, the majority concluded that COMSAT's highly unusual mixture of private ownership and a degree of Government control offered an appropriate balance between the great efficiency inherent in private ownership and the need to protect the public interest. Comsat's ability to compete effectively with foreign challengers was not an important factor in its establishment, precisely because satellite communication technology was in its infancy at the time, and the United States was the unchallenged leader in the field.

By contrast, Arianespace was established in order to maximize the European competitive challenge to NASA's near-monopoly in the provision of reimbursable launch services. Development of the Ariane vehicle and its variants was and will continue to be managed by the European Space Agency, but once the Ariane series becomes fully operational the marketing of launch services will be carried out by Arianespace. ESA member states may have concluded that this approach offered the best prospect of cost-effective operations unrestricted by the inevitable legal and political obstacles that confront any government agency seeking to engage in commercial competition.

Ownership and other aspects of the Arianespance organization also differs from the Comsat organization. Comsat is entirely privately owned, with the provision that no more than fifty percent of its voting stock be held by the international record carriers. Arianespace ownership, on the other hand, is vested in fifty shareholders made up of thirty-six major European aerospace firms, thirteen European banks and the French Government's Centre Nationale d' Etudes Spatiales (CNES). Ownership is carefully apportioned among these shareholder organizations so that approximately sixty percent is French, twenty percent German and the remainder divided among the other ESA member states. Virtually the same apportionment has been made of the development costs for the Ariane family of vehicles, which will be borne collectively by ESA.

Over the years, the U.S. international record carriers gradually divested themselves of their ownership interest in COMSAT, which today is widely held by individuals. However, there appears to be no prospect for a similar evolution for Arianespace. The Arianespace Convention established a close relationship between the company and ESA; and the management officials foresee that relationship continuing at least until renegotiation of the terms of the Convention in 1986.

Mr. PEDERSEN. I would say that perhaps the one item of significant difference is that Arianespace maintains a significant degree of government involvement. I believe that CNES, the French Space Agency, maintains something like 30 percent ownership in Arianespace, which makes it of a different character than, I think, Comsat.

Senator SCHMITT. Comsat started out with that, but it turns out it evolved in time.

Mr. PEDERSEN. I know of no intent to evolve Arianespace. I think the French Space Agency intends to remain a signficant hand in it. I will provide some additional information.

Senator SCHMITT. We would appreciate it.

[The statement follows:]

STATEMENT

OF

Mr. Kenneth S. Pedersen
Director of International Affairs

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Science, Technology and Space
Committee on Commerce, Science and Transportation
United States Senate

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to be here today to testify on NASA's international space activities.

NASA has enjoyed a long history of successful cooperation in space activities with other countries. This past year has been no exception. We have experienced some exciting events, the fruit of years of hard work and effort by NASA and its partners. We have also planted the seeds for some new cooperative ventures for the future. I am pleased to report that NASA's Fiscal Year 1983 budget request provides continued strong support for these international programs.

This past year has also been marked by indications of increasing foreign competitiveness in space activities. Growing foreign capabilities and expenditures have produced a group of mature foreign space powers, capable both of competing effectively with U.S. firms for worldwide business and serving as highly competent partners for new and different kinds of cooperative activities.

Today, I would like to address all of these items.

1981 Highlights

First, I would like to briefly summarize some of the highlights from the past year. These activities demonstrate the many benefits both NASA and our foreign partners realize from cooperative endeavors.

The European Space Agency (ESA), in December, delivered the first Spacelab flight unit, consisting of a pressurized module, which will provide scientists a shirt-sleeve environment for conducting experiments in orbit, and pallets on which to mount scientific experiments. The first Spacelab unit, which ESA is contributing to the Space Transportation System, cost the Europeans close to $1 billion to develop and produce. ESA has begun work on fabricating the second flight unit which NASA is procuring under a contract with ESA.

Two European scientists completed basic mission specialist astronaut training at Johnson Space Center in 1981. Claude Nicollier, a Swiss astronomer, and Wubbo Ockels, a Dutch physicist, were accepted into the astronaut program in recognition of the substantial contribution ESA is making to the STS. Nicollier is continuing his training as a mission specialist in preparation for possible flight assignment on Shuttle missions carrying European payloads. Ockels, meanwhile, has transferred to the Marshall Space Flight Center for payload specialist training in preparation for the first Spacelab flight now scheduled for September 1983. There he joins Ulf Merbold of Germany, who is also preparing to be a payload specialist for Spacelab 1.

Some Spacelab hardware has already been put to use in space. During the second Shuttle orbital test flight (STS-2), a set of experiments were flown in the Shuttle cargo bay mounted on an ESA Spacelab pallet. A significant amount of important data was collected and is now being analyzed, demonstrating the success of the pallet concept and design. A second set of experiments will be flown on a similar ESA pallet during the third orbital test flight (STS-3).

The STS-2 mission also incorporated the successful first flight of the Remote Manipulator System (RMS), also known as Canadarm. Canada has invested close to $100 million in the design and development of this complex piece of equipment. Although the STS-2 flight time was shortened, nearly 80% of the RMS test objectives were met. It was operated in all of its modes ranging from fully automatic to fully manual. Its television cameras at the wrist and elbow provided good visual coverage of the Columbia. Finally, the arm was successfully swung back and latched along the left side of Columbia's payload bay. More tests will be conducted on STS-3 and subsequent flights.

The first payload to be deployed by the RMS will be on the third operational flight. The German company Messerschmitt-Boelkow-Blohm (MBB) is reimbursing NASA to fly that payload--a MBB-developed Shuttle Pallet Satellite (SPAS-01)--on the Shuttle. NASA and MBB last year signed a Launch Services Agreement covering this flight. This and other activities during 1981 show a continued growth in international planning for use of the Shuttle. In April, NASA and the Federal Republic of Germany signed a Memorandum of Understanding to cover all of Germany's planned Shuttle activities, including reimbursable Spacelab missions, 25 Small Self-Contained Payload flights, and a variety of planned or proposed cooperative ventures. Earnest money payments were received in the past year from France, Colombia, Brazil, Japan and Canada to reserve space on the Shuttle. Just last month, we negotiated a Memorandum of Understanding with Colombia that foresees the launching of two communications satellites on the Shuttle in 1985. Over 50% of all civil payloads already booked to be flown on Shuttle are foreign, and NASA is currently talking seriously to a number of other countries on possible future Shuttle use.

I am confident that NASA can continue to count on solid international support in the testing and future operation of the Space Shuttle. Early in 1981, we completed agreements with Japan and Spain for the use of contingency landing sites in case the Shuttle must make an emergency landing. STS-1 and -2 received tracking support from stations in Australia, Ascension Island, Bermuda, Chile, the Indian Ocean, and Spain. Moreover, stations in Australia, Botswana and Senegal provide UHF air to ground communications. We recently reached agreement with Senegal to add S-band telemetry support, which we expect to be operational for STS-4.

Significant milestones were reached in two Explorer programs which have international participation. NASA and Germany's Ministry for Research and Technology signed a Memorandum of Understanding for development of the Active Magnetospheric Particle Tracer Explorer (AMPTE). In order to understand Sun-Earth interaction through active chemical release, the German spacecraft will release ions which the U.S. spacecraft will track as they enter the magnetosphere. Additional measurements will be made from a sub-satellite to be provided by the United Kingdom which will fly close to the German spacecraft. AMPTE is planned for a 1984 launch.

Major progress was also made during 1981 on the Infrared Astronomical Satellite (IRAS). IRAS is a cooperative explorer project with the Netherlands to conduct a comprehensive all-sky survey in the infrared region of the spectrum. The U.S.-built telescope was shipped to the

Netherlands last spring where it was integrated into the Dutch-built spacecraft. The spacecraft was then fully tested in the Netherlands and returned to the U.S., where it is undergoing final preparations for launch in late 1982.

International interest and participation in NASA's Landsat remote sensing program continues to grow. In 1981, NASA signed an agreement with Indonesia allowing for direct reception of Landsat data by an Indonesian ground station in exchange for payment of an access fee and potential backup support, if needed. That ground station is now under construction. A ground station in Thailand became operational late last year, thus bringing the number of operational ground stations to twelve in ten countries. Chinese contacts with U.S. suppliers of ground station hardware also intensified in 1981, indicating the possibility that a ground station contract will be signed this year to implement their 1980 agreement with NASA.

Last summer, a number of foreign investigators were selected to participate in our geodynamics program, the study of tectonic plate movement to try to understand why earthquakes occur. One major focus of this program is the Western North American plate, which will involve close cooperation with selected investigators from Canada and Mexico. A second objective is the coordination of measurements of plate movement on a global scale, and many foreign investigators have been selected to participate by both gathering and analyzing this data. This effort will involve substantial coordination with experts in Europe, Japan, Australia and Latin America and includes a first-ever NASA agreement to cooperate with Chinese investigators in data analysis.

NASA is participating actively in interagency preparations for the 1982 U.N. Outer Space Conference, called UNISPACE '82, to be held August 9-12 in Vienna. UNISPACE '82 will focus on the practical benefits to be gained from space science and technology activities, and in particular, how these benefits can be realized by the developing countries. There are already significant U.S. efforts underway in response to the desire of developing countries to increase their involvement in space activities, and the U.S. will emphasize these efforts at the Conference. UNISPACE '82 will also offer countries the opportunity to learn about other aspects of the U.S. civil space program which could be useful in social and economic development.

During 1981, NASA continued its efforts to involve developing countries in programs that could directly benefit them. For example, the remote sensing program that I have already mentioned brings developing countries information which they can use to more effectively manage their resources. NASA continued to discuss with developing countries participation in our global geodynamics research program as I just described above. Through programs funded by the Agency for International Development and the Department of Energy, solar cell technology originally developed to power spacecraft is being used to supply electricity to rural villages. Small stand-alone photovoltaic systems are helping to meet basic needs such as refrigerator storage for critical vaccines and pumping of fresh water.

The FY 1983 Budget Request

As I noted earlier, NASA's FY 1983 budget request supports the continuation of NASA projects that involve international participation.

Of great significance to our international community of future Shuttle users is that this budget request moves the Shuttle program out of the development and test phase and into the initial operational stage. The first Shuttle operational flight is currently planned for a November 1982 launch. This budget request also continues procurement of the second ESA Spacelab unit and additional RMS hardware from Canada to outfit the currently planned Shuttle fleet.

A 1985 launch of Space Telescope is supported by NASA's FY 1983 budget request, an event eagerly anticipated by the whole international science community. The Space Telescope will be the most powerful observatory ever built, giving us a much closer look at the planets, stars, and galaxies. Since it will operate outside the earth's atmosphere, it will be able to detect objects 50 times fainter than ground-based observatories. ESA is contributing the solar arrays, the Faint Object Camera, and some scientific ground support, a contribution worth approximately $130 million. In return for its contribution, ESA will play an active role in the Space Telescope Science Institute operations, now being built at Johns Hopkins University.

The FY 1983 budget request also supports a 1985 launch of the Galileo mission to Jupiter. Germany is cooperating with NASA in this mission by contributing the retro-propulsion module for mission maneuvers and insertion of the spacecraft into orbit around Jupiter.

As the Members of the Subcommittee recall, budget constraints last year required NASA to eliminate the U.S. spacecraft from the International Solar Polar Mission, a joint mission with ESA. While I do not want to underemphasize the distress this necessary action caused both sides, I believe that both NASA and ESA are determined to maintain good cooperative relations. Both the Administrator of NASA and the ESA Director General have recently confirmed their commitment to the principle of continued cooperation between the U.S. and Europe in space.

activities. I am pleased to report that this budget request permits NASA to meet our continuing ISPM obligations to provide launch services, tracking and data acquisition support, the radioisotope thermoelectric generator (RTG) power supply, and support for the U.S. experiments that will be flown on the single European spacecraft. Of the nine investigations to fly on the spacecraft, five have U.S. Principal Investigators and three of the four European investigations have U.S. Co-Investigators. This budget request also funds development of an auxiliary propulsion module needed to launch ISPM on the Shuttle/IUS in 1986.

Development of the Gamma Ray Observatory (GRO) will continue under this budget request. GRO will further explore some of the mysteries of the Universe such as black holes, gamma ray bursts and supernovae. Germany and the Netherlands are participating in instrument development and the UK will join us in analyzing data from the mission, currently planned for a late 1988 launch.

An active Spacelab utilization program which involves significant foreign participation is supported by this FY 1983 budget request. Spacelab 1, scheduled for a 1983 launch, is a cooperative NASA/ESA mission with multi-disciplinary science experiments, and will be the first flight of the Spacelab module-plus-pallet configuration. Spacelab 2, planned for a 1984 launch, will carry two instruments developed by the United Kingdom, and the ESA-developed Instrument Pointing System (IPS) is scheduled to fly for the first time. A scientific instrument to investigate cosmic rays developed by India will fly on Spacelab 3, scheduled for a 1984 launch.

This budget request supports two important ongoing activities keyed to observing Halley's Comet. Although the ESA "Giotto" mission is not a cooperative mission, U.S. scientists are participating. Nine of the ten European instruments selected by ESA for the mission have U.S. Co-Investigators with a total of 32 U.S. scientists involved. NASA is providing limited support to the U.S. scientists for consultation, limited design effort, some instrument calibration activities, and the development of one instrument, the Ion Mass Spectrometer. NASA also plans to provide ESA reimbursable tracking support by the Deep Space Network. In addition, this budget request will be used to begin establishing the international observing networks for the International Halley Watch. These networks of groundbased observatories are being established to provide continuous coverage of the Comet, and will be jointly managed by a U.S. scientist and a European counterpart.

The budget supports the 15-month demonstration phase of the Satellite-Aided Search and Rescue (SARSAT) program, a humanitarian program designed to reduce the time to respond to emergency signals from aircraft and ships by using satellites to detect these transmissions. Canada and France are our partners in this activity, and the Soviet Union has agreed to join this project by making sure its satellite system called COSPAS is interoperable with SARSAT. This multilateral demonstration could begin as early as this year. Norway has recently signed on to be an investigator during the demonstration, and negotiations are underway with several other countries which also wish to participate. The budget also requests funds to develop instruments for additional satellites to continue search and rescue satellite coverage on an interim basis until an operational system is established.

NASA's Geodynamics Program will also be continued under this budget, with additional measurements planned in several locations around the world to further our understanding of earthquake causes. International interest in both gathering and analyzing this data continues to grow.

As you can see from the above discussion, this budget request maintains most of the currently planned space science and applications missions that involve international participation. However, reductions were made in some areas of the NASA budget consistent with the Administration's efforts to reduce government spending and control inflation. One such reduction affected the Venus Orbiting Imaging Radar, a planned mission to study Venus in order to better understand the Earth's evolution. NASA has decided not to undertake its development at this time, which affects foreign investigators from Australia, Canada, Austria, the United Kingdom and France who had been tentatively selected as members of the science team.

COMPETITION

In the past decade, we have seen measurable growth in foreign space budgets and capabilities. This growth has raised concerns about increasing foreign competitiveness with the U.S., both in terms of technological levels and in the space hardware market. I would like to briefly address these very real concerns.

Many foreign space budgets rose steadily throughout the 1970s, although there has been some leveling off recently as other countries experience a period of fiscal restraint similar to the U.S. situation. However, the budgets have been maintained at fairly high levels compared to the past. Furthermore, recent foreign budgets have shown an increased emphasis on areas of potential commercial payoff: communications, remote sensing and launch vehicle development.

The members of the Subcommittee are familiar with many examples of this foreign challenge and I will not do more than list a few items today. ESA has successfully completed the testing of its Ariane launch vehicle, and the first operational flight is scheduled for next month. ESA recently approved funding to further upgrade the Ariane vehicle, with plans to develop and test the Ariane 4 vehicle by late 1985. Several countries, most notably France and Japan, are developing land and ocean remote sensing satellites. Communications satellites have been developed and are being sold by a number of foreign firms, and both ESA and Japan are emphasizing experimental work in the potentially commercially important 30/20 GHz band.

This competition should come as no surprise. The potential market for space hardware and services is large and technically challenging. Indeed, it would be surprising if U.S. leadership in this area was not challenged. What is of concern, however, is the increasing evidence we see that foreign governments are adopting sophisticated strategies to enhance and aid their aerospace industries' competitive positions. Many foreign governments support their space industry not only through R&D funding, but also by price subsidization and financing assistance, development of attractive package deals, and creation of quasi-governmental marketing organizations.

For example, the Europeans have established Arianespace, a semi-private corporation, with extensive French government involvement, to market Ariane launch services. Arianespace has contracted with Grumman Corporation to be its U.S. marketing agent. Arianespace's marketing strategy combines aggressive salesmanship with attractive prices, made even more attractive by government supported financing terms.

We see a similar situation emerging in remote sensing. Here, France has created a largely government-owned corporation called SPOT-Image to market the data products produced by its land remote sensing satellite, SPOT, now scheduled for launch in 1984. In addition to the marketing of SPOT data, SPOT-Image will promote the sale of related French commercial equipment and services. Like Arianespace, SPOT-Image will establish a U.S. subsidiary to pursue business here.

I am confident U.S. industry can meet the competitive challenge to its leadership. To help industry meet this challenge, NASA's FY 1983 budget request continues support for research and technology in the fields of remote sensing, space launch vehicles, and other advanced program developments. In addition, in the area of launch services, NASA is aggressively pursuing improvement programs to lower production and operating costs and facilitate user relationships.

The U.S. Government's efforts must be complemented by vigorous private sector R&D activities and by aggressive marketing of the resulting products and services. What additional role the federal government can play, particularly in such areas as financing and providing assurance that U.S. firms are not victims of unfair competitive practices, is currently being studied by the Administration.

Cooperation--What Lies Ahead

It would be unfortunate if the focus on competition were allowed to divert our attention from those areas where international cooperation offers significant benefits. No single nation can pursue fully all fields in science and technology during this period of worldwide fiscal restraint. Cooperation has permitted NASA to reduce mission costs, gain valuable access to foreign scientific and technological expertise, and support important U.S. foreign policy objectives. As I have said to this Subcommittee before, competition and cooperation are not necessarily mutually exclusive. Increasing capabilities abroad also can make foreign nations more capable partners.

To reap the benefits of cooperation without jeopardizing the competitive position of U.S. industry, care must be exercised in selecting, defining and implementing joint programs. Projects leading to the early development of commercially useful technology are not usually open for international participation. In projects where there is foreign involvement, that involvement is structured so as to avoid technology transfer. Generally, foreign participants undertake to provide a discrete piece of the overall project and are then responsible for developing the resulting technology and hardware. Only the minimum amount of technical information necessary to ensure effective interface among the various elements of a project is exchanged. Although I have heard concerns expressed about technology transfer, I believe that the facts support my claim that if technology is transferred, very little significant technology escapes the U.S. as the result of NASA's cooperative programs.

It is important to note that cooperation can also be a factor in reducing competitive challenges and maintaining U.S. leadership. Cooperative programs frequently link foreign space objectives to our own, for example, when other countries develop Shuttle-compatible systems. Such partnerships have the effect of supporting our goals and may divert foreign resources from competing programs.

As times change, it is imperative that we constantly evaluate our methods. I anticipate that NASA will need to entertain new modes of cooperation with foreign space agencies in the coming years. For example, NASA has traditionally funded the major share of cooperative projects with foreign partners playing a more minor role with regard to total mission costs. However, ambitious foreign space budgets and increased capabilities abroad mean that we no longer need to play that role in all cases.

In fact, foreign partners are taking larger roles in several recent missions we have agreed to jointly undertake. The Dutch and United Kingdom investment in the Infrared Astronomical Satellite project is almost equal to the U.S. investment. The same is true of the AMPTE project with Germany. We welcome this kind of 50/50 partnership, and expect more of our potential partners to assume larger shares of the responsibility.

Moreover, NASA can now for the first time contemplate cooperative ventures where we are not even the primary actor. We are discussing with Germany the possibility of participating in their ROSAT mission, planned for 1986, which would provide valuable X-ray data to the U.S. scientific community at a time when NASA has no similar mission planned. I would not want to rule out U.S. instruments flying on missions where our foreign partners provide the spacecraft, launch, and even the tracking and data acquisition. We are currently discussing the possibilities for such missions with several prospective partners.

Looking further into the future, several foreign nations have expressed interest in what our future plans beyond Shuttle may be. One possibility opened up by an operational Shuttle is the establishment of permanent presence in space. Representatives from foreign space agencies have attended general briefings on some of the future Shuttle-related concepts we have been studying. While it is premature to conjecture about what NASA's next major mission may be and whether foreign participation in it will prove mutually beneficial, I can report that foreign interest in being part of NASA's future is high.

In summary, the outlook for international cooperation, both in the short and long term, is good. This Administration has expressed its strong support for international approaches. In this regard, I can do no better than quote the words of Vice President Bush to an audience of U.S. and European space officials gathered last month at the Kennedy Space Center on the occasion of the delivery of the first Spacelab flight unit to the U.S.: "Let us continue to be partners, in this and in all fields. And let me take this opportunity to assure you that we intend to continue our international cooperative programs, just as President Reagan recently reconfirmed the commitment of the U.S. to a vigorous space program."

Thank you, Mr. Chairman. I would be happy to answer any questions you or your colleagues may have.

Senator **Schmitt**. We appreciate your attention this morning and we will now recess for about 15 or 20 minutes while we clear the room for the remainder of this hearing.

[Whereupon, at 10:15 a.m., the subcommittee recessed, to reconvene in executive session.]

Executive Session

Senator **Schmitt**. The hearing will come to order.

It is a great pleasure to have with us today in closed session the Honorable Richard DeLauer, Under Secretary of Defense for Research and Engineering, to give the Defense Department's perspective on space and aeronautics activities.

Dr. DeLauer, it is a great pleasure to have you here. For so many years we have been in and out of association. You have been doing a great job for us over there in Defense, as you did in the private sector before. I hope that you will introduce your principal colleagues and proceed to give us a summary of your testimony as is appropriate. Then we will proceed to have some discussion.

STATEMENT OF DR. RICHARD D. DeLAUER, UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING, DEPARTMENT OF DEFENSE, ACCOMPANIED BY DR. ROBERT COOPER, DIRECTOR OF ADVANCED RESEARCH PROJECTS AGENCY

Dr. **DeLauer**. Thank you, Mr. Chairman.

Dr. Robert Cooper is with me. Dr. Cooper is the Director of Advanced Research Projects Agency and is also my senior research engineering deputy on advanced technology and research. Between the two of us, I think we ought to be able to answer most of your questions.

I would like to enter my statement for the record, Mr. Chairman, give you an opening statement, and then proceed to the questioning, if that is all right.

Senator **Schmitt**. That if fine. Please proceed.

Dr. **DeLauer**. I do not think there is any question in most people's minds about where I as an individual stand on support of the space effort. Personally, I have been working with space business since the early fifties and have always been a firm believer that space assets——

[Discussion off the record.]

Dr. **DeLauer**. In my present job, my responsibilities are such that I have to really take a look at the resource allocations that we have for all of advanced technology and development and be sure that we have a balanced program meeting all the defense needs, of which space is a most important segment. Our science and technology base is our future lifeline.

So I hope that this morning we will be able to present to this subcommittee the fact that we have a balanced program, that we are not neglecting areas of high potential, and that over the next few years we will be able to really get on the road of putting those advanced capabilities into the equipment of the Defense Department.

I am not going to dwell on the threat. Most of us are aware of the Soviet space program and the Soviet technology program. It is large, it is ambitious. They know the value of space and, different from ours, they do not make any distinction between military and civilian use of space. They use it for political purposes and they are very well aware of its value as a means of indicating the technology level of the country.

Now, let me move right into the DOD space activities and in a summary form just tell you what we are trying to do. Our emphasis, of course, is in support of the force structure. We are becoming more and more dependent upon space capabilities for communications, navigation, weather, and surveillance. I do not think we could operate today without space communications, not for long, anyway.

Our biggest effort at the present time is to be sure that we continue to make sound investments in the space effort. We have to make these investments along the lines of making systems which are survivable and making them endure.

Now, in the 1983 budget we have asked for $8.5 billion for defense space programs. That is over and above the $6.24 billion which was appropriated in fiscal year 1982. This represents about a 20-percent real growth.

During the last year NASA's Space Shuttle Columbia flights were significant. It proved beyond a question of a doubt that reusable spacecraft are indeed a viable alternative and that we can deploy, retrieve, service, and repair operational platforms from them.

I do not have to remind you that NASA is the lead in the Shuttle. This is in consonance with previous commitments made to allocate resources between NASA and the Department of Defense and forms the basis for managing and funding the programs. On the other hand, the Department of Defense is absolutely dependent upon the Shuttle. In this budget we have a considerable amount of money budgeted for the activities to develop, bring on line and finish the construction of the Shuttle launch facilities at Vandenberg. Our future space activities from Vandenberg are going to be almost exclusively dependent upon the Shuttle as the booster.

I do not have to tell you anything about the Air Force's desire to have a consolidated space operations center (CSOC). It is being developed. It is going to support two roles which are well defined: Satellite operations and Shuttle missions in the later period of the decade will be controlled from the CSOC.

In the last year and a half we completed the definition of the new MILSATCOM architecture which is the heart of the communications part of the Department of Defense's space programs. In the eighties we will have deployed the DSCS III's, FLTSAT—we have added three additional FLTSAT and we will bring the LEASAT program into operation for tactical and general purpose forces. In the meantime we will start the development of the new MILSTATCOM. The RFP for the program definition of the next generation of satellite communications is out. The teams are lined up, and I think we are going to have a very good competition.

A question before Congress at the present time, and one that the Department of Defense is supporting wholeheartedly, is the global positioning system. This is a program that has been long in coming, too long in coming in my opinion. It should have been here before.

It is a program that probably represents the most integrated program, not only with the Department of Defense assets, but also with those of the civil aviation, with our European allies, with the maritime users, and offers great opportunity for us to have a long-term very, very useful system.

GPS is one that is going to take a considerable amount of funding in 1983 and we need your support on continuing that program.

Senator SCHMITT. Are we going to have wholehearted Defense Department support this year for that? We had to really squeeze that turnip pretty hard last year before we got even reasonable support. It was principally a battle in conference. It is one of those items, as I understand it, which is still locked up in the appropriations-authorization debate.

Dr. DELAUER. In discussions with some other committees of Congress I have been asked the same question and I have had to answere it in kind of an indirect way. There is no question that the Department of Defense supports the GPS.

When I say the Department of Defense, I mean the whole Department of Defense. On the other hand, in this process of resource allocation in many cases there is a process which we loosely call the gold watch. The services recognize a gold watch when they see it and the GPS happens to be one. So there is a certain reluctance for the services to put that very high on their list, since they know it is going to be insisted upon.

On the other hand, this causes me quite a bit of trouble in Congress, because I keep getting asked by different committees, well, if it is so important why does not the Air Force have it first, or why does not the Army have it first, or why does not the Navy have it first.

All I can say to them is that, you get them in and you ask them whether they are going to support the GPS and the answer should be affirmative, notwithstanding what they might have as a listing of a set of priorities.

Senator SCHMITT. Well, I will tell you, as the lead arguer for this in conference, I think we had better—I will not dwell on it right now, but we better figure out a way to make sure that our colleagues in the conference understand this is important, and that we do not have to give away other things in order to keep it.

That is the problem. Once you have to negotiate in conference you are going to lose something else.

Dr. DELAUER. That is bad, because this is a good program. The difficulty I have at the present time, and we have had for the last year or two, is we are asked for absolute assurances by some other committees that if they approved GPS, we would show a long list of things that we will no longer require. We are putting this list together. Futhermore, they want to put a time scale on those and that tends to be kind of hard to estimate before we get the GPS system up.

Just an aside, and as a matter of fact, in a subject that you have considerable influence and interest in, and that is the question of the use of our military assets for civilian use. I had a visit from the representatives of the maritime trade associations. They have a kind of group. One of the people that came to talk to me was in the geophysical services area involved in petroleum exploration.

One of the issues in the GPS is the access to the very highly precise capability, which has to be done through an encryption process, and they wanted to request of me that they would not be overlooked. Now, hand in hand with that is the whole question of user charges. The user charges for non-DOD users in both the very highly precise mode or in the less precise mode varies by about a factor of 10. Their view was, notwithstanding anything, we will pay anything to be able to use the high precision capability.

They are going to plan to have it completely part of their whole program. But those things are going to continue as we go along. To try to forecast exactly what the user community will take at this stage of the game is just speculation.

Senator Schmitt. Let us see if we cannot get it coordinated, and maybe somehow you could establish a DOD priority list that is over and above the priority listing of the other services.

Dr. DeLauer. It is. That is why it is the gold watch.

Senator Schmitt. The way you described it they all assume they are going to get it, so they do not put it on their list. But when we get over here and try to save your cookies it is a little tough when it is down on the priority list.

Dr. DeLauer. Well, not to dwell on it this morning, but you might be aware that my old organization invented GPS. It was not called GPS then. We had NAVSTAR, I guess, at the time, and the Air Force sold it. Then there was a forerunner. 621–B was before that. But the Air Force was hot for it, and now that they have it they put it down on a lower priority.

Senator Schmitt. Let us move on. But you know, every time we get that we give up something else we want when we get to conference.

Dr. DeLauer. I do not want to get to conference with it. I want everyone to approve it right out.

Now, we continue to support science and technology in space. Bob is here today to talk to you when you want to talk about some of the ARPA programs, which include the particle beam technology, and it includes the laser development work we are doing, that will be space-based laser activities.

But supporting all that systems application are a broad array of technologies, both in surveillance and warning—infrared detectors and onboard signal processing. It is going to be clear that our very high-speed integrated circuit program, which the Defense Department is pushing very hard, is going to be the heart of any synthetic aperture radar that we want to have.

We are pushing large optics and we are producing other aspects of putting things in space such as cryogenic refrigerators and all the things that are necessary to put some of these sensors into space.

Now, as far as our aeronautics activities——

Senator Schmitt. Let me ask a question. Has DOD done an analysis of the advantage and disadvantages of helping to maintain the landing capability for defense-related missions at White Sands?

Dr. DeLauer. I'm not familiar with anything we have done on that.

Senator Schmitt. Could you supply it for the record if you have, because White Sands Missile Range is a secure area.

For certain DOD missions I suspect it might actually be an operational choice.

Dr. **Cooper**. We will supply any analyses we have done on that.

Senator **Schmitt**. There is an energy advantage to White Sands, and when you look at weather, Vandenberg weather or even Kennedy weather, normal landing areas in the operational phase, you still have some high statistical probability of having to go into pretty bad weather. So if you would supply that for the record.

Dr. **DeLauer**. We will supply that for the record.

[The following information was subsequently received for the record:]

While it is true that White Sands Missile Range does have potential advantages (weather and security) as a landing site for the Shuttle, its use as a primary landing site during the operational Shuttle era would be inefficient. If the Shuttle were to land at White Sands, it would have to be ferried back to the launch base via the Shuttle carrier aircraft. This would add at least an additional week to the ground turnaround time (time from Orbiter landing until fewer flights per year and an attendant increase in the cost per flight. The routine use of White Sands as a landing site would require construction of a facility to safe and deservice the Orbiter, remove any payloads which were returned with the Orbiter, and prepare it for the return ferry flight. A mate-demate device, used to load the Orbiter on the ferry aircraft would also have to be constructed. Frequent landings at White Sands would require installation of the instrumented landing system (Microwave Scanning Beam Landing System) which will be available at both launch and landing sites. The ferry flights of an Orbiter from White Sands to either Kennedy Space Center (KSC) or VAFB are not attractive since they introduce additional risk and cost to the program. In general, we feel that for optimized Shuttle operations, the Orbiter must land at the primary landing site (either KSC or VAFB) and that the facilities and environment at these locations are adequate to support our operational requirements. The capability to land the Shuttle at Edwards AFB will be maintained in the event that both of the primary sites would be unavailable for a landing. Thus, we see no requirement for Shuttle landing at White Sands, other than in an emergency, once both KSC and VAFB are fully operational.

Senator **Schmitt**. We are finally getting everyone to think about White Sands, after 10 years.

Dr. **DeLauer**. The aeronautics program of the Department is large, $3.7 billion for fiscal year 1983, of which 10 percent is for aeronautics technology development. We have been working with NASA and we are trying to aline our programs with them. In general we are urging NASA to continue the basic technology aspects of aerodynamics and aeronautics while we will bias our activities toward the systems applications—the kinds of platforms we are looking for—and fund those. We hope to keep NASA's technology program on a very firm base. That is the area that needs the best people on a continuous basis, whereas the systems aspect tends to go up and down depending on the threat.

Senator **Schmitt**. Let me ask you to comment a little bit more. The support that DOD gives to NASA aeronautics is of course a support in areas that you see as directly or indirectly related to the defense mission. And I accept the fact that you are supporting NASA in that respect.

However, in areas of research and technology for aeronautics that do not directly support DOD missions we seem to have a significant cutback. For example, the aeronautics programs that we have seen canceled by NASA which do have indirect impact on potential defense missions are the following:

Composite primary aircraft structure, energy efficient transport, energy efficient engine, advanced turbo prop laminar flow control, aeronautical system studies, integrated aerospace vehicle design, aeroelasticity of turbine engines, helicopter transmission technology, tilt rotor systems technology.

I do not think any of those would be classified as systems, although they might have systems aspects to them. But on the surface they seem to be technology that NASA has had to give up.

Dr. DeLauer. But we are picking them up. We are picking up every single one of those things.

Senator Schmitt. Why do you not just reimburse NASA to do it?

Dr. DeLauer. Because in some cases they are not the best ones to carry out that research or that development. Let me give you an example. Let us take the whole question of tilt rotor or tilt nacelle. Ames has been doing a lot of work on this technology. We want them to continue the basic work.

But we are in the position now where I have established a joint program—the JVX, I guess we call it—which is for the purpose of configuring the next generation of vertical lift aircraft. It is a joint three-service program being directed by the Army. NASA is participating, but we are funding that program. That program will include an assessment and evaluation of the existing technology, not only what has been done at Ames but what has been done in the industry.

We are ready to have a systems configuration. Now, when that happens and we decide whether it is going to be tilt rotor or tilt nacelle or some other configuration, then NASA will get back into the act by helping us to look at that particular configuration. But we have had to make a decision with regard to their role and we believe that in this case it is better for them to use their resources on other things as long as the technology is not being neglected.

Everything that you have mentioned there is not being dropped. The bail is not being dropped. We are picking that one up.

Senator Schmitt. But you know, the tradition was that NASA would said in many of these areas.

Dr. DeLauer. They have.

Senator Schmitt. And in that way you have much more ready access to the commercial sector, in addition to DOD getting the advantages that they want.

Dr. DeLauer. That is not quite true in those things you are talking about. They have done the basic work. Now we are getting into it, because the people that are going to be doing the effort are not NASA nor defense. We have a bunch of contractors that do it. Every single one of them have their products accessed to the commercial sector.

Let us take the engine development. NASA has done some fundamental work. They have done some good work on some good propellers, which we are trying to continue. Now are are getting to the point where we would like to apply some of that basic technology to new military engines or to improvements in in-service engines. It is GE, Pratt & Whitney, Garrett and a few other contractors who will do it. They also have their markets in the civil area. This is the form of transition to military systems that we want to continue.

Senator **Schmitt**. But that transition has all of this R.&.T gradually moving over into the Department of Defense, and I frankly do not think you believe that that is a good trend, whatever you say on paper. What is being done is to have it all under the umbrella of the Defense Department.

Dr. **DeLauer**. Well, I assert that it is not all going under the umbrella of the Defense Department.

Senator **Schmitt**. You just said you are picking all of this up. We would like for the record more specifics on this.

Dr. **DeLauer**. We will give you the list—it is a short list—for all the things that are going on.

Senator **Schmitt**. But these are ones that NASA has specifically canceled.

Dr. **DeLauer**. That is right, and we have picked up on them.

Senator **Schmitt**. And for our record we would like to have that detail on each one of those items and how you are picking them up; and also, why you see that there will be no delay and no added impediments to the commercialization of some of these technologies, because we have a tremendous foreign competitive threat in the commercial sector and if it just takes a year longer to get some of these technologies out into the private sector as a result of DOD leadership on this we are going to lose the market.

[The following information was subsequently received for the record:]

DoD CONTINUATION OF NASA PROGRAMS

The Department of Defense will be providing a logical continuation of those programs terminated by NASA in the context of applying the already developed technology base to our specific military system needs. A more specific enumeration for each of the terminated programs is as follows:

Composite Primary Aircraft Structure.—[Deleted.] This DoD program will have direct application to the commercial transport industry. A multitude of by-products will also surface through on-going DoD efforts from the all composite helicopter fuselage, and a critical wing box center section for fighter type aircraft. We are also pursuing the development of metal-matrix composites with structural performance similar to non-metallic composites but having the capability of being worked with existing tools and machinery.

Energy Efficient Transport and Laminar Flow Control.—Both of these technology thrusts have principal applications to a new transport aircraft design. As such, the impact of the NASA program could not be felt until the next transport (C-5 replacement) acquisition. Within the technology base, we have on-going programs in all three Services in active control technology and propulsion/airframe integration for producing more efficient airframe designs. To the extent that these technologies are applicable, they will be incorporated in our next generation transport or Navy patrol craft. We did make a KC-135 available to NASA for testing of winglets which demonstrated a 6 percent reduction in cruise drag and we will continue to work in this area.

Energy Efficient Engine.—The component technology which has been, or will be, demonstrated in this program is of course available to the major NASA contractors, General Electric and Pratt and Whitney. To the extent that this technology is applicable to our advanced technology engine needs, it will be incorporated into the major DoD technology demonstration programs, Advanced Turbine Engine Gas Generator (ATEGG), Advanced Propulsion Subsystem Integration (APSI), and Joint Technology Demonstrator Engine (JTDE), in which both General Electric and Pratt and Whitney participate. Our understanding is that NASA plans to use the engine hardware in-house at Lewis as advanced technology testbeds, and so the program will also continue in this manner.

Advanced Turboprop Systems.—It is our understanding that NASA plans to continue the basic technology effort associated with the unique element of this program—the prop-fan, and we view this effort as very important. Although the acquisition of the additional C-5 transport aircraft precludes an opportunity for near-term military applications of this technology, it should be of great benefit in the development of a C-5 replacement planned for sometime around the year 2000. Accordingly, we shall continue to follow NASA's work in this area very closely, and we are actively considering appropriate complementary efforts in our advanced propulsion technology programs within the next few years.

Aeronautical Systems Studies and Integrated Program for Aerospace Vehicle Design.—These programs deal with the development of a computer software system for total management of aerospace vehicle design; and mission, systems, and conceptual analyses for advanced civil and military aeronautical systems. While the NASA military studies were coordinated with the proper DoD elements, they were of generic types of aircraft, rather than focused on a specific operational requirement. The Military Services conduct similar studies aimed at somewhat more specific requirements and tend to be more near term. If NASA activities are eliminated in this area, DoD must broaden the range of our studies to insure that development of far term technology requirements are not overlooked.

Aeroelasticity of Turbine Engines and Helicopter Transmission Technology.—These are rather modest programs (a total of $2.4 million in fiscal year 1981, an initial request of $1.5 million in fiscal year 1982, and a current estimate of $0.8 million in fiscal year 1982) which are joint programs with DoD. Our efforts in these areas will continue, and we will endeavor to augment these efforts in order that progress will not be unacceptably slowed.

Tilt Rotor Systems Technology.—The XV-15 program has been jointly funded by NASA and DoD. Both NASA and the Services are continuing to fly the aircraft in operationally oriented tests. The Navy will be taking the XV-15 to sea this summer for limited trials on board a LPH or LHA class ship. The tilt rotor is a prime candidate for the new Joint-Service Veritical Lift (JVX) aircraft development program.

With regard to any delays in transition of the basic NASA technology to specific commercial systems, we feel that any such delays will be determined largely by commercial market needs. We think that those technology developments which have timely commerical applications will be immediately applied by the contractors. In addition, inasmuch as the major contractors are concerned with both military and commercial systems, DoD activities should provide added impetus to applying the technology to commercial products.

Dr. DeLauer. But I do not see where that is particularly germane to the technology base we are talking about. Movement into the commercial marketplace has been the most rapid in the engine area and in the airframe area.

Senator Schmitt. But we are seeing a tremendous competitive surge in the world market in commercial aircraft and design related to commercial aircraft, and my concern is that, even though all the technology effort may be going on under DOD's auspices, the incentive for moving the technology into the commercial sector is going to be less. It has traditionally, and that was one of the reasons for NACA. NACA existed in order to accelerate that transfer.

That is what concerns me. And again, the Space Act gives NASA the national mission for research and technology in aeronautics, and it appears that everything they will be doing now is in cooperation with you for defense purposes and less and less for civilian purposes.

Dr. DeLauer. Now, that is not quite true. I cannot let you state that without a response. Let us take one program that is on the list, composite structures. [Deleted.]

[Deleted.]

Now, if you look at what it takes to put composite structures into the civil aviation, it takes facilities, it takes know-how, and it takes manufacturing capability. And where is all this going to be done? In Seattle.

Senator Schmitt. But is is also going to take a declassification.

Dr. **DeLauer**. No. It is not going to take any declassification of the manufacturing technology. The fact is that the autoclaves are there. Why do you think the Boeing Co. is so interested in this program?

Senator **Schmitt**. So you think that the Boeing Co. and other industry companies are perfectly happy to see the DOD have prime responsibility for aeronautical R. & T.?

Dr. **DeLauer**. Certain areas where we can get into these systems efforts fast enough and move them out of technology is where NASA should be—in the technology area. Now we are moving it out of technology into applications.

We have been working on composite structures for 20 years. As a matter of fact, some of the carbon fiber structures were attempted in the Rolls Royce RB-211 engine and they fell on their face.

Senator **Schmitt**. As I listen to you, I am having trouble seeing from your perspective that there needs to be a NASA aeronautics——

Dr. **DeLauer**. No; we want them to have it.

Senator **Schmitt**. What is it? You are saying that anything NASA drops you are picking up? What is it?

Dr. **DeLauer**. No; I did not say that anything NASA drops. I said together we have rationalized the aeronautical research program so that they can focus on certain things and we will focus on others. We will not have duplication.

Senator **Schmitt**. What is NASA's role in aeronautics?

Dr. **DeLauer**. NASA role is aerodynamics. NASA's role is fluid dynamics. Their role is advanced concepts in these areas. Their role is in stability and control, both the testing and the understanding of it. That is their role in the aeronautics side. [Deleted.]

This is a big thing. It is expensive. It is very hard to do. That is what NASA should be doing. That is what NACA did.

Senator **Schmitt**. You do not think NASA should be in the business of taking the technology and adapting or expanding it as necessary for specific civilian applications? You think the industry will handle all of that based on——

Dr. **DeLauer**. If it has in the past, it will in the future. That is my own personal opinion.

Senator **Schmitt**. Does industry agree with that?

Dr. **DeLauer**. I think so. Why do you not ask them?

Senator **Schmitt**. The problem with industry is they figure they have everything they wanted with the B-1 and they are afraid to testify in favor of anything else.

Dr. **DeLauer**. I do not think that is the case.

Senator **Schmitt**. Talk to them and you will hear that.

Dr. **DeLauer**. As a matter of fact, if you look at the engine business, the commercial engine business, the military is not helping them much at all, other than giving them some business. The civilian engine market is fundamentally a different market than the military engine market.

Senator **Schmitt**. Well, I am glad you feel that the pie has been carved up properly, Dick. I have my own reservations. I think we are getting far too much of that over in the Defense Department. One of the tremendous advantages that NASA, and preceding that NACA, gave the country was rapid access to unclassified activity.

Dr. DeLauer. Mr. Chairman, let me also assert that in my own personal view I have felt that NASA has neglected the aeronautics field in the last 15 years.

Senator Schmitt. You and I are in full agreement on that. One of the reasons is that the space side——

Dr. DeLauer. Has taken too much money.

Senator Schmitt [continuing]. Has taken too much of the money and management attention.

What we are trying to do is find some way to change that so that NASA can contribute whatever uniquely it should contribute to the aeronautics side. Right now the trend seems to be in the other direction. All we see is cancellation of NASA activities rather than an enhancement of NASA.

Dr. DeLauer. I would suggest that perhaps it is not a cancellation, but a redirection and rationalization of the activities they are best suited for and the ones we are best suited for.

Senator Schmitt. I am prompted to say that the public perception or at least the perception up here, so far as the public pays any attention to this, is that it is all in favor of the Department of Defense. NASA is not going to be in a position to offer the commercial sector, the nondefense sector, the kind of aeronautics R. & T. services that they have in the past.

Dr. DeLauer. But the Defense Department R. & T. in the aeronautics area is available to the commercial sector. They are the same people. There is no difference between the commercial producers of aircraft and the Department of Defense producers of aircraft, certainly not in the engine business, certainly not in the airframe business.

Senator Schmitt. That is true over the long haul, but my concern is that we are in a very intensive competitive period. And I hope my mind is still open on it. I am not sure it makes any difference whether it is open or closed.

Dr. DeLauer. On the one hand I know that you want us to pick up greater funding of the space activity, particularly that of the Shuttle. That is essentially what we have done. We have picked up the funding of certain aspects of the aeronautics program so as to lighten the funding load on NASA so that they can concentrate what available funds they have in areas where they have the greatest capability. We offload them in areas where we have capabilities and make our products available to them.

In the area of joint programs we meet quarterly. We go over all of the programs. The people at the working level talk to each other every day. [Deleted.]

Senator Schmitt. Well, I agree with the concept that you have articulated. My concern is that there are some commercially or economically related activities that NASA ought to be doing, that either fall through the cracks entirely or are going to be submerged within DOD because of the emphasis, not only in the Government but also in the industry, related industries, on the defense-related activities, and they just will not get transferred into the commercial sector fast enough to compete with what we have to compete with abroad.

Dr. **DeLauer**. I think you have a point. My only point to you, Mr. Chairman, is that the aeronautics activity is the wrong example.

Senator **Schmitt**. Do you have an opinion why our competitors abroad in certain areas of aeronautics are in fact taking portions of markets that we used to have a monopoly on?

Dr. **DeLauer**. Yes; I have an opinion. In 1973 we permitted the export of the core of the B-1 engine to France for use in the CFM-56 engine. That eventually provided them an organic capability in large engines that they would not have otherwise had.

On the other hand, Rolls Royce is reasonably good, but they were behind. They made a bad mistake in the choice of how to build the RB-211. As a matter of fact, that's what put Lockheed in terrible shape. They lost 2½ years on the market because of problems with the composite blade. So that hurt Rolls Royce. We have certainly profited from the work they had been doing on engines for vertical takeoff.

But in the commercial sector it has been a nationalistic drive.

Senator **Schmitt**. Targeting by particular areas?

Dr. **DeLauer**. Yes; and they subsidize. The A-300 is not a viable program. Without major subsidies, both by the Germans and the French, the A-300 would never survive.

Senator **Schmitt**. Are we going to be able to compete in that environment?

Dr. **DeLauer**. No. I will be frank with you. My own estimate is that we will be down to one major commercial airplane company. We only have 1½ now. We have Boeing and a little bit of McDonnell Douglas Long Beach. McDonnell Douglas Long Beach is primarily a DOD contractor for the KC-10 for the next 3 years. Their commercial orders are not that much.

Lockheed is out of the commercial business and there is nobody left. We are going to have two major engine manufacturers. That is going to be a good dogfight in the commercial area. Our military support of both these engine contractors is about even. GE looks like they are going to be more of a supplier of the bomber modernization. When you look at the fighter program, with the upgrading of the F-100 engine, I think if Pratt & Whitney does a good job they should be in the fighter program through the year 2000.

We will have a tremendous engine capability. The only other two will be Rolls Royce and SNECMA, unless the Japanese decide to make an investment.

The commercial side of aeronautical transportation is going to be down to one or two contractors. It is a real problem.

Senator **Schmitt**. Why do we not proceed?

Dr. **DeLauer**. Well, I have covered some of this.

Bob, do you have anything to add about aeronautics?

Dr. **Cooper**. Well, basically I wanted to bring out one point and that is that Defense really does concentrate on Defense-peculiar needs in its basic aeronautics research programs. NASA does basic research that has broad applicability.

We are concentrating only on things that are peculiar to Defense needs, by and large. I think the point that Dick made was that for those technologies that mature in NASA, we are there. We are ready to pick up and to transition them into our peculiar applications. I think the industry has to be there and ready to take those technologies that mature in NASA and apply them to commercial potential use.

I think it is in reasonable balance right now. That is, I believe that the NASA programs and the Defense programs are in reasonable balance in those relationships.

Dr. DeLauer. And we do support NASA when we use their unique facilities. There is no question that we are going to use most of their facilities.

Let me pick up, however, on areas that I do think this committee ought to have a concern about. I do not have an answer for you. I will tell you what we are trying to do and that is to transfer into the civilian sector much of the space-related capability that we have in the intelligence area.

Classified intelligence and purely military space activity that we have are being reviewed to possibly transfer these capabilities into the civilian sector to supplement Landsat data for geophysical service activities. Those activities are indeed ones that we are not doing a very good job on at the present time. We do not have an answer on it. We are trying to work the problem.

I would like to point out that this is the first unveiling and all I will do is wave it. This is our first coordinating draft of DOD space policy. We are going to address things that you have shown an interest in in the past, Mr. Chairman.

Let me, for the record, read what this contains. It is going to be a secret document when it is finished.

Senator Schmitt. Will there be an unclassified version?

Dr. DeLauer. Probably, at some time.

Senator Schmitt. I would strongly encourage that you develop an unclassified version.

Dr. DeLauer. We talk about national policy, defense policy, and civil space activities. We are going to show how we relate to the military issues, the political issues, and economic issues. Some of the things you are talking about have economic overtones.

The process of how we formulate space policy is a thing you have been concerned about. It is in small segments and it has not coalesced in the Department. We are now trying to do that. We are trying to look at alternate policy issues—if we go this way what does it mean, if we go that way, what does it mean. Then we are going to come up with a recommended policy, an issue that you have considerable interest in is included. What should the DOD's long-term interest be in the use of the space transportation system?

At the present time we say our policy is that we will fund, support, utilize the space transportation system for military missions as it is now developed by NASA. But we have as issue No. 2; What is the longer term option? Should the Department of Defense take over the funding, management and operation of a space transportation system for military use?

Those will all be contained in this. We are attacking the whole policy.

Senator Schmitt. Will that include an assessment of the impact of various defense scenarios?

Dr. DeLauer. We intend to do that, yes.

Senator SCHMITT. For example, you and I both can imagine scenarios where the four Orbiters are booked up with a legitimate mix of defense and nondefense payloads, and then all of a sudden bells start to tingle a little bit, if not ring, and the priority is exercised and the nondefense side begins to go under.

Will you assess that?

Dr. DELAUER. We will assess that and show the impact because we do that now on other things. It is partly our job and partly FEMA's job, but we do that on the civilian side. We have an aircraft program which essentially provides the ability to commandeer civilian aircraft for use in a critical situation.

Senator SCHMITT. But you also pay for some of the modifications.

Dr. DELAUER. We pay for the modifications and we pay for the additional costs to the airlines to carry those modifications. We have plenty of analogous situations that we could use in this area, as well as in other areas.

Senator SCHMITT. What is your target date for that?

Dr. DELAUER. Well, I talked to the policy people this morning. We should have a coordinated copy in mid-April.

Senator SCHMITT. Really, can we get an unclassified version simultaneously? I am really going to need that.

Dr. DELAUER. You might get an unclassified summary. But as you know, the real heart of the Department of Defense space policy is how we are going to use it.

Senator SCHMITT. I understand that. But you know, also, Dick, one reason we are losing some battles up here is because we sit around and say, I am sorry, we cannot tell you why we need it.

Dr. DELAUER. You probably cannot declassify the aspects of the plan that are peculiar to particular classified issues—[deleted]. But certainly the things you are interested in—how does it interact with the civilian community, how does it interact during an emergency—are certainly unclassified subjects.

Senator SCHMITT. An example of the problem we run into, National Security Decision Directive No. 8, which is classified confidential—that is not very high, but still we cannot use it. And there is nothing in there that is going to cause any problem, but it is classified confidential and we cannot show that, at least at the Presidential level, there is a fairly significant commitment to this for defense purposes and for civilian purposes.

I would love to have that unclassified.

Dr. DELAUER. I will work to get some of that declassified.

Senator SCHMITT. I think people have been working on trying to declassify that for several months, and they have not yet. And that is not a very big declassification.

Dr. DELAUER. As you know, it is easier to stamp "confidential" on a piece of paper than it is to cross it off a piece of paper.

Senator SCHMITT. I am responsible for reviewing your new executive order on that subject.

Dr. DELAUER. Fine. You can give us some help.

Let me conclude and then get on to any questions that you have. I have not touched on the shortage, and what looks like a continued shortage of engineers. I think it ought to be as much of concern to this committee, as it is to us. We are trying very hard to use our resources in a way that will help reverse this trend.

I have just finished a review of the I.R. & D. program. These funds are independently managed but reimbursed by the Department of Defense and NASA for companies to do their own tech base effort. We are providing incentives for them to use the universities. I think it will be productive. We will keep you apprised of how we are doing in that area.

Senator SCHMITT. Is General Hillsman your principal—is he the fellow that is coordinating this?

Dr. DELAUER. No; General Hillsman is doing—he is a big supporter of the communication interactions.

Senator SCHMITT. He is the only one that has really talked articulately about this subject in open session.

Dr. DELAUER. I cannot talk articulately about it, but my research office R. & A.T. is the focal point within R. & E. for this activity.

Dr. Leo Young in Bob's organization provides staff support to me on this. As you know, I am the cochairman of a DOD university forum which was put together by the AAU. This forum includes the presidents of most of the centers of excellence. We are going to meet three to four times a year, establish some task forces, and operate a little bit like the Defense Science Board. We plan to critically examine many of these issues that are between the Department of Defense and the utilization of the universities.

We have just finished a Defense Science Board study by Ivan Bennett on the responsiveness of the universities to DOD needs. We will get you a copy of it.[1] I am meeting this afternoon with Frank Press of the National Academy of Science to undertake a much broader look at the whole question of technology transfer. We plan to examine our interaction with not only academia, but technical societies and certain other foundations, on how to handle this question of technology transfer and interaction between them and ourselves in technology discussions. They will take the lead on that.

We are working on a broad spectrum of technology transfer problems with the universities and with the National Academy of Sciences.

Senator SCHMITT. Is there any measure of budgetary emphasis on this?

Dr. DELAUER. Yes.

Senator SCHMITT. What are you doing in terms of dollars?

Dr. DELAUER. Well, we have a few programs.

Senator SCHMITT. Maybe you could supply that for the record.

Dr. DELAUER. We could put it in the record. We have the university instrumentation initiative and we have some money in the fiscal year 1983 request for it. Each of the services has a fellowship program, of which the Office of Naval Research program is probably the most advanced and the one that I am quite pleased with. That program is well underway.

Putting the I.R. & D. incentives into the companies to use the universities in their area to help do work will be a big help. It will force them together.

[The following information was subsequently received for the record:]

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[1] The report has been retained in the committee files.

SUPPORT OF UNIVERSITIES

Within the constraints of our mission, DoD is striving for better ways to support university research. Basic research has had a 5.8 percent rate of real growth per year since 1976 and we anticipate real growth from fiscal year 1982 to fiscal year 1983 in excess of eight percent. When we account for the increased university portion of this basic research funding, it projects to an increase of about 12 percent in real growth for them. In addition, there is increased emphasis on interdisciplinary and block grants and increased emphasis on multiyear funding to universities to level out the hills and valleys that have tended to characterize research funding.

Our basic research programs also indirectly support many graduate students. For example, a Navy study conducted in fiscal year 1980 shows that the Office of Naval Research supports an estimated 2,000 graduate students (some partially) through its contract research programs. The number for all three Services is probably close to 4,000 graduate students.

Army, Navy and Air Force have all initiated fellowship efforts, and will be supporting more than 100 graduate fellows by fiscal year 1983. The Air Force fellowship program focuses on thermionic engineering, advanced composite structures and research in aircraft technology; the Army currently plans emphasis on computer sciences, vertical lift technology and advanced materials. The Navy will target its fellowship support to students in electrical engineering, computer sciences, naval architecture, applied physics, materials sciences and mechanical and aerospace engineering, and is implementing this program with the help of the American Society for Engineering Education.

The summer faculty program at our DoD labs provided summer research opportunities to more than 200 faculty members last year and authorizations for next summer are increased.

Attention is also being given to research equipment upgrade to replace the obsolete equipment hampering university research. The DoD has committed $3 million to Joint Services Electronics Programs for fiscal year 1982 and is encouraging a government-wide program for equipment upgrade in fiscal year 1983. On a broader scale, the Department has increased the percentage of contract support going toward equipment purchase from four percent (fiscal year 1976) to ten percent (fiscal year 1981) in its research contracts with universities.

We also continue to encourage closer university-industry relationships. For example, DoD is exploring incentives for industry to support university research through the independent research and development (IR&D) program.

A new section of the recently passed Defense Authorization Act of 1982 enables our R&D laboratories to contract with educational and non-profit institutions for the research services of college and university students. Regulations to implement this program are currently being developed.

Dr. COOPER. We also have a new initiative to create two new major centers of excellence in computer science and technology in the next 3 years. So we will be expanding our efforts to create faculty and graduate students in that area.

Senator SCHMITT. Is this in coordination with the intelligence community at all? That is one of the areas they mentioned as their biggest concern.

Dr. COOPER. Yes, we have an intelligence, research and development committee which coordinates these kinds of activities, and we are communicating with them on that.

Dr. DELAUER. I chair that committee, and we have all the users as well as the producers of intelligence as members of the committee. NASA also sits on that committee.

Senator SCHMITT. What is your estimate of the annual shortfall now in advanced degree holders in science and technology relative to defense and nondefense needs? NSF and Labor have estimated 10,000 a year. General Hillsman testified he thought it was probably closer to 50,000 a year.

Dr. DELAUER. Well, General Hillsman is in the communications business and generally they are hurt more than anyone because they have been neglected over the years. There is the real emphasis on C^3 now because it has gone from essentially dot-dash into digital activities.

Senator SCHMITT. But what do you think is the shortfall?

Dr. COOPER. The estimate by the National Academy of Engineering is in the tens of thousands.

Dr. DELAUER. I can make it available for the record. We do have that number.

[The following information was subsequently received for the record:]

SCIENCE AND ENGINEERING PERSONNEL

While numerous studies have been conducted to identify S&E shortage categories nationally, these studies often conflict in their conclusions and vary in their recommendations. What does appear to be emerging, however, is a general consensus that some shortages do exist, particularly in such areas as electrical engineering and computer sciences. OUSDRE is now looking into questions of how these national shortages affect DoD-related requirements for certain types of scientists and engineers, and over the coming year, will be making policy and program recommendations for DoD-wise action.

In general, the supply/demand problem for the decade of the 1980's has not been fully sorted out. Of greatest concern at the current time, however, is the shortage of doctoral level engineers. While the number of freshman enrollments in U.S. engineering programs rose 89 percent over a recent five year period, the number of full time engineering professors has fallen by 2,500 or 15 percent in this same time period. In 1980, almost 10 percent of the 16,200 permanent full-time engineering faculty positions in U.S. engineering schools were unfilled, resulting in student-faculty ratios growing from 20 to 1 to 50 to 1 in some schools. It is expected that 30 percent of engineering faculty positions will be unfilled by 1985. Furthermore, four out of every ten engineering graduate students are foreign, as are almost 5 of every 10 engineering doctorate recipients.

Four percent of all scientists and engineers in the United States are employed by the Department of Defense in both civilian and military positions. While data projecting DoD civilian employment shortages is not yet available, the Services have estimated a shortage of almost 8,600 M.S. and Ph. D. officers over the next five years. Among the disciplines most in demand are: aeronautical, electrical and electronics, civil, mechanical and general engineering, as well as computer sciences.

Dr. COOPER. There are some things to be said on that issue, though, as far as Defense is concerned. Even with the substantial number of advanced degree holders that we have coming out of our universities, many of them are inaccessible to Defense because of the fact that nearly 50 percent are foreign graduate students, many of whom are returning to their countries of origin, rather than being available for doing defense work.

Senator SCHMITT. I understand.

Dr. DELAUER. I think that is an area that Congress ought to look into.

Senator SCHMITT. We are trying to.

Dr. DELAUER. Particularly, over the years the immigration rules have changed and it gets discouraging for a fellow who is really trying to get the best brains working on a problem to see that we let all the rejects show up and we take care of them and feed them and everything else. All the bright ones we educate and send home. It does not make sense.

Senator SCHMITT. There is good economic reason for that. That is what has been supporting the graduate schools of this country, since our people have not been going into graduate school.

Dr. DELAUER. No question about it.

Senator **Schmitt**. The industry, and probably to some degree the Government, hire our best baccalaureate degree holders before they can even consider getting into graduate school. And then we turn around and hire the faculty that would have been there to teach them had they gone.

Dr. **DeLauer**. We are in violent agreement.

Senator **Schmitt**. That is what has to change. The industry is telling me through the President's transition team or former transition team that in spite of increased investments, they just do not see it happening from the industry side; that the Government is going to have to provide a lot of funds. And I am not sure I fully agree with that.

Dr. **DeLauer**. I do not agree with that. I was involved with setting up the center for integrated systems at Stanford in the last 2 or 3 years and it was a combination. It is in the microelectronics area and we really did set up a multidisciplined organization.

The Government was precluded from providing the money for brick and mortar, things like that, and John Young, Bob Noys, and myself were able to organize an effort that ended up giving them close to $8 to $10 million over a 2-year period out of industry organizations. It took less than a year to do it.

The thing that was attractive was that Stanford said, we are going to graduate 100 M.S.'s and 30 Ph.D.'s a year out of this place. Everybody's eyes just opened up and they put the money in. You spend more than that recruiting. Furthermore, the companies can be part of the process and help run the place by sitting on the steering committee.

So there are ways to do it if you are imaginative enough.

Senator **Schmitt**. Mr. Secretary, your statement is very persuasive, at least in my mind, that the Soviets are moving toward a permanent manned presence in space. Would you agree with that?

Dr. **DeLauer**. There is no question that they are. It is a question of the time scale.

Senator **Schmitt**. Well, what is your assessment of the reasons they feel that that is important? Is it really psychological? Do they have an idea about man's importance in space that we do not have, or what?

Dr. **DeLauer**. Well, I think that they do. I think that they tend to recognize the fact that there is a military utility for men in space. I think they recognize the fact that they had what I would consider a very political-intellectual shock on the world with Sputnik. That was wrested away from them over a period of time. They would like to get that back.

Certainly, their failures in their lunar programs have not set well with their leadership. Our lunar program was certainly a great accomplishment, both technically as well as politically. I think they recognize all of these things. Since they put so much more of their GNP into the military side and do not separate military from nonmilitary utilizations, they have resources allocated that are quite large. And as you know, once they start a program and build a team, it has a life of its own.

Senator **Schmitt**. Do you think they have changed their attitude toward the manned capabilities in space? You remember all the evidence in the early days was that they really did not trust the use of man in space. They fail-safed to the system rather than failing safe to the man.

One philosophical implication of that is a difference in their approach and ours. It cost them some lives as a result of that. I would say all four of the deaths they have had in space were a combination of failing safe to the system rather than the man, and also an inferior technology base, such as in the use of cold gas rather than hypergolics for attitude control.

Do you see that this is all behind them now? Do they have the idea that man can exercise independent judgment, heaven forbid, in space that would have a military capability of its own?

Dr. DeLauer. I do not think it is behind them. I think it is part of their basic way that they attack a problem. I think that everything you have said has led them to some of the results because they had early success and then they had early failures, failures that they did not seem to take. They did not change their direction very much. They plodded on with them.

There is a tendency for them to do that, even in their weapons work. They just go on and brute force gets them through. I just think they are going to make what their program entails be a success.

Bob, you have been working with this as much as I have.

Senator Schmitt. But you still have not told me what they expect to do with a man in space, because our defense establishment has generally felt that man in space does not have much of a role when it comes to operation of military activities.

Dr. Cooper. To get to the core of your question, which is have they changed their assessment over a period of time of the utility of space, they have clearly throughout the life of their manned space program looked at both civil and military possible utilities of space.

The experiments they do on Salyut are clearly both related to their military needs as well as to doing scientific experimentation.

Senator Schmitt. But most of that is related to the military needs also, is it not? Materials processing? Are they not looking for new materials? They are not looking for new materials to make a better automobile for the Soviet people.

Dr. Cooper. Possibly. But they also do scientific work. They look at fundamental spectra of stars and things of that sort as we did on the Skylab, for instance. But I believe that they have spent much more of their time and effort trying to understand the military utility of a human presence in space. If there is any place where they lead us in their manned effort in space it probably is in the understanding of what man can add to their security needs.

Senator Schmitt. Are you implying that we know more about that than they do?

Dr. Cooper. No, I am saying they know more about that than we do. There is no question in my mind.

Senator Schmitt. No one seems to be particularly concerned about it.

Dr. DeLauer. I guess I have to wax philosophical for a minute here. A decision was made 23 years ago that the U.S. manned space program would be focused on nondefense objectives and characteristics.

There was a fight in the Defense Department at the time. As a matter of fact, we continued a program called manned orbiting laboratory.

Senator **Schmitt**. The first graduate of that program will by flying Monday, Gordon Fullerton, and also a classmate of mine from Cal Tech.

Dr. **DeLauer**. Now, I am going to get around to you in a minute. But you are only one side of it. Where did the majority of the astronauts come from? They came from the military side. They were military aviators in most cases, or military engineers, scientists later, and then a mixture with some civilians. I guess you were one of the very first civilians.

I can go back to your experience. How much did you two talk about the military utilization? Pretty soon you got caught up in the system and the military guys ceased to be military and they became astronauts.

Senator **Schmitt**. We talked about it an awful lot, but there was no ear. There still is not an ear. There still is no obvious priority interest in discussing what unique role man would play as a permanent presence in space for military purposes or for certain of the very short-term excursions into space.

That really does not seem to be a topic of discussion other than a bunch of us get together over a few beers and we talk about it. We talked about it a lot, though, because we feel that the Skylab experience as well as the Apollo experience and the fact that you did have operational military pilots who thought those kind of thoughts of, how would I act in space if I had a military mission, what could I do that nothing else could do, those were there and there was a lot of thought, informal thought, that has been given to it, but formal——

Dr. **DeLauer**. It never got into programmatic activities. You know, we had a chance. Tom Stafford became assistant chief of staff for development within the Air Force.

Senator **Schmitt**. Well, that is what I am asking. Is it because there has been some decision——

Dr. **DeLauer**. How do you start in a big institution like DOD? You start by saying you have a mission. When you have a mission, then you start examining how you could do that mission with space assets.

Senator **Schmitt**. You see, Dick, that is what is in the back of my mind. I look with disbelief at what seems to be the prevailing opinion that four orbiters is going to be enough, or even five is going to be enough. As soon as we really do start to examine what the fundamental military role for a man in space is going to be, the nature of platforms, what they are used for, what real time reconnaissance is all about, how it is integrated with the Earth missions of the various services, I would be surprised if eight orbiters is enough.

That is what concerns me, that we will economically lose a great deal by foreclosing options today that, by the time that is assimilated and a few other thoughts are assimilated, we will suddenly realize that we are going to have to reopen or try to reopen. Then you have a much more difficult time politically in reopening those options than you do in maintaining them today.

Dr. **DeLauer.** It is not clear to me, Mr. Chairman, that if we critically examine military utilization of man in space, that the orbiter would be the right vehicle.

Senator **Schmitt.** But it is a transportation vehicle.

Dr. **DeLauer.** It is transportation, and we are using it. I will submit that DOD is taking advantage of what the STS is supposed to be. It is supposed to be a transportation system for space-deployed assets and we are taking advantage of it.

Senator **Schmitt.** All I am saying is, Dick, I would feel a lot more comfortable if the Department of Defense and NASA were saying that we have to maintain the option of buildng a fifth orbiter simultaneously with turning that into a Block II orbiter that fits the mission that we have not defined yet. But at least keep that option open.

Dr. **DeLauer.** Well, it has not been closed.

Senator **Schmitt.** It is getting closed. There is no money in NASA's budget for long lead items.

Dr. **DeLauer.** There is some. We need more.

Dr. **Cooper.** In 1982.

Senator **Schmitt.** But not in 1983. The 1983 budget does not contain the fifth orbiter money.

And I do not think it would have contained fifth orbiter money in 1982 if some people up here had not insisted on it.

Dr. **DeLauer.** Let me suggest to you that certainly in the NASA budget there ought to be enough money to continue the orbiter production activity, buy the long lead items and keep the line open.

Let me suggest that perhaps NASA should sit down and reexamine exactly what the roles and missions of NASA should be in order that the space transportation system be given a high enough priority to be funded within the resources allocated to them. I understand that such a study has been made to exactly how NASA should look in the eighties. The results of that study have some very fundamental changes that would have to take place in NASA structurally. From an infrastructure standpoint I think this may be the time that it should be done.

I urge this committee to ask the NASA people to revisit that study which was done a few years ago.

Senator **Schmitt.** Well, I think the subcommittee will do that and is doing that. But we also have to ask the Department of Defense to revisit their previous positions.

Dr. **DeLauer.** We will do that, sir.

Let me bring you a message from the Secretary, because I covered your concerns with him this morning. He said to tell Senator Schmitt that, "I support the Shuttle." He says, "I was in OMB when it was first proposed. I supported it then and I support it now."

Senator **Schmitt.** I have heard that. I appreciate that comment from the Secretary. But I am still concerned about the public statement, that undercut our efforts, that the Shuttle is not a high priority. But anyway, let us leave that as it may. We have discussed that on other occasions, formally and informally.

There is a program called advanced military space flight capability program. Does that ring a bell?

Dr. **Cooper.** Yes, I do know that program.

Senator **Schmitt**. Is it a new military space transportation system that you are looking at?

Dr. **Cooper**. No. That program, Mr. Chairman, is looking basically at the future needs that the Defense Department has for space transportation. It will try to understand and characterize the long-term needs and the potential that technology has to support those needs.

Senator **Schmitt**. Is it conceivable that a proposal for a Block II Orbiter, if you will, would come out of that?

Dr. **Cooper**. It could come out of that.

Senator **Schmitt**. Lighter weight capability and more rapid turnaround system, building on the experience of the first block?

Dr. **Cooper**. That is right. One of the concepts that is being looked at in that program is the single stage to orbit concept. This concept has been funded at a low level by NASA in the past and looks potentially very attractive for increasing the survivability of a space transportation system similar to the Shuttle.

Senator **Schmitt**. Survivability in a defense context.

Dr. **Cooper**. That is correct. For instance, it would be able to operate from commercially available airfields throughout the United States and go from horizontal takeoff to orbit with a single stage. It is an attractive concept from the standpoint of making the vehicle and its basing survivable.

Senator **Schmitt**. Does that require a new generation of fuel?

Dr. **Cooper**. No; stages are based on LO_x and hydrogen. It does require an all-titanium vehicle where the skin and the tankage are integral. It is a very advanced concept and requires new technologies to be developed relating to welding of titanium structures.

Senator **Schmitt**. It is probably easier than building a titanium submarine that goes 660 feet under the ocean.

Dr. **Cooper**. Possibly.

Dr. **DeLauer**. We do not have one of those, either.

Senator **Schmitt**. Gee, that is right, we do not. Somebody does, I heard.

Dr. **DeLauer**. They do.

Senator **Schmitt**. What about expendable launch vehicles? Do you think there is a need to develop a new generation of expendables for the Department of Defense?

Dr. **DeLauer**. The same study that Bob was just relating to you would include expendables, as well as reusable systems, as part of how does it match our needs. It would even include ballistic missile launch vehicles.

Dr. **Cooper**. In addition to this programed activity in Defense, recently the NASA Administrator, Mr. Beggs, and Dr. Mark, his deputy, came to visit with Dr. DeLauer, Frank Carlucci, any myself to talk about the prospect of looking at Shuttle-derived launch vehicles, essentially unmanned, where parts of the system would potentially be expendable.

We agreed that we would work with NASA to look at military requirements and the need for such vehicles. There is now an ongoing study focused in NASA, but with Air Force support, looking at a potential Shuttle-derived launch vehicles, essentially unmanned, where parts of the system would potentially be expendable.

We agreed that we would work with NASA to look at military requirements and the need for such vehicles. There is now an ongoing study focused in NASA, but with Air Force support, looking at a potential Shuttle-derived, partially expendable, partially retrievable launch system.

Senator SCHMITT. But primarily in order to enhance the total payload, rather than as a substitute for other capabilities.

Dr. COOPER. That is correct.

Senator SCHMITT. Do you think we need to develop expendable launch vehicle capabilities, payload capabilities comparable to those that the Soviets appear to have developed?

Dr. DELAUER. In some areas, yes. I think there is no question that we would like to have [deleted].

[Deleted.]

Senator SCHMITT. What about vulnerability of satellites for defense purposes? Obviously, if somebody wants to put a nuclear weapon on something like that, that would be the end of it.

Dr. COOPER. [Deleted.]

Senator SCHMITT. [Deleted.]

Dr. COOPER. That is correct.

Dr. DELAUER. [Deleted.]

Dr. COOPER. Typical times to get to synchronous orbit are 4 to 7 hours for direct ascent. In that period of time, just a few hundred feet per second of Delta V can put 1,000 miles between you and the position where you were previously located. [Deleted.]

Senator SCHMITT. [Deleted.]

Dr. DELAUER. Yes, sir.

Senator SCHMITT. Are you convinced we are on the right track, at least for the short term, on the atmospheric launch and ASAT capability?

Dr. DELAUER. I think our program is probably one that at its present state of development, we ought to complete before we start on the next generation.

Senator SCHMITT. We have brought into an extraordinarily expensive effort; have we not?

Dr. DELAUER. The ASAT program is not inexpensive. Even though it is F-15-based and you look at the support requirements to quickly convert the F-15 to that capability, and all the necessary ground support equipment, it is not an inexpensive operation.

Senator SCHMITT. Are you confident that the on-target reliability of the system is going to be such that it will be worth the cost?

Dr. DELAUER. I think so. I think it is a pretty good program.

Senator SCHMITT. There are no show-stoppers in the system?

Dr. DELAUER. When I last reviewed it I thought that they were well enough on the track that it was one of the programs we delegated complete management responsibility to the services. One of the initiatives we are trying to institute in the Department is controlled decentralization, primarily just from a management viewpoint. As a consequence, this was one that the Air Force is taking on. I have not reviewed it recently.

Have you had a chance, Bob?

Dr. COOPER. No, not recently.

Dr. DELAUER. They are supposed to come back to me if they have any problems and they have not.

Senator SCHMITT. I hope you stay on top of it. I would hate to see us break the whole basket of eggs.

We are going to have an awful lot of questions for the record. This has been a very helpful discussion. Let me ask one very specific question in conclusion. NASA has indicated to us that they believe the solar maximum mission repair is an important demonstration of a capability for rendezvous repair and/or retrieval, and it will help sell their program to the Department of Defense.

It is my judgment, just so you know where I am coming from on this, and I think the judgment of most of the astronauts who have been in space, that we have already demonstrated that capability and we should not have to sell that to the Department of Defense.

What is your position?

Dr. COOPER. Sir, I would like to address that question. As you well know, I was there at the beginning of that program for the multimission modular spacecraft. It was through no inconsiderable effort on my part that I was able to convince NASA to actually undertake the development of the MMS and to use it initially for the solar maximum mission spacecraft as well as the Landsat D and D′.

It was my feeling at that time at the Goddard Space Flight Center where the development was undertaken that without a clear demonstration of the capability to retrieve the spacecraft in lower orbit and return it to Earth and/or repair it on orbit, that the capability would not be widely used by NASA project managers. The reason is because project managers are very cautious people. Until a capability has been demonstrated in its intricate detail they are reluctant to use that capability in their project. It is just a built-in conservatism.

Senator SCHMITT. That is a pretty expensive way of making project managers feel warm, because really a major part—they have demonstrated every aspect of the SMM mission.

Dr. COOPER. Except for the retrieval itself and incorporation into the Shuttle using the current remote manipulator system and the Shuttle hardware and some of the changeout concepts that are there on the MMS spacecraft.

Senator SCHMITT. If you examine all the things we have done in Earth orbit missions, as well as lunar missions, you will find that you could put together all those pieces.

Dr. COOPER. Sure. But there are a few questions having to do with things like the contamination of the spacecraft by various gases that are exuded from the Shuttle as it approaches. There are questions of exactly how the spacecraft would survive reentry.

Senator SCHMITT. And you think that if those answers all came out negative in some way that we would not then proceed for use of this capability?

Dr. COOPER. No, but I think that the information that will be gotten from going through with that mission will be useful and will give project managers a great impetus to incorporate the appropriate design to cope with the conditions which are encountered and which are then understood. If the information on all of those aspects is not available, then there is a potential barrier to get over in widely applying that technology.

Senator SCHMITT. Well, if I had project managers as conservative as that in my organization, I would get rid of them. I really would. That is just too damn conservative.

Dr. COOPER. It is a matter of cost and the perception that——

Senator SCHMITT. You are right; it is a matter of cost. It is another one of these items that you guys think in terms of billions and we think in terms of a few tens of millions in order to preserve some other activities within NASA, and here we see NASA trying to justify this mission on the basis of selling the capability to the Department of Defense.

Dr. DELAUER. That was not the way it was started out. It started to sell the capability to NASA, not to the Department of Defense.

Senator SCHMITT. I understand, but that is not what they are saying now.

My understanding is the Air Force is currently looking at a chemical release module experiment. What is it and could you give me the status of it?

Dr. COOPER. That is a plan to examine the structure of the Earth's magnetic field using chemical release systems that would be deployed from an expendable launch system. It is a part of our basic physics program to understand the space environment in the vicinity of Earth so that we can cope with these environments in designing and building our spacecraft.

Dr. DELAUER. The Air Force is picking up the cost of launching the system and NASA is to pay for the system integration. We will immediately share the information with the nonmilitary community.

Senator SCHMITT. Are you familiar with an article that appeared in the Scientific American in December, I believe, that strongly suggested that directed energy weapons in space were nonfeasible?

Dr. DELAUER. I am familiar with the article, but that is as far as I have gone. I did not pay any attention to it.

Senator SCHMITT. I asked the Air Force Weapons Lab to give me a critique on that. If you had any other ideas on that article and the principles that have been articulated there, we would appreciate having it for our record.

Dr. COOPER. I can do that now, Mr. Chairman. That article was written by a research associate at MIT named Kosta Tipis. I know Mr. Tipis quite well. I have discussed with him on occasion his ideas about space-based laser weaponry. Mr. Tipis has a personal policy of avoiding contact with the military space-based laser community or the high-energy laser community, the classified community in general, so that his ideas are not influenced strongly by any research activities that have gone on in the Defense Department.

He bases the analysis that he makes on first principles. In many cases the assumptions that he makes—and he must make some assumptions about the scale and size of certain aspects of the systems which he tries to create—he makes fundamental assumptions [deleted].

If you take the contention of all of the assumptions that he makes and design the system with those assumptions, the system performance does not look very good, particularly in the highly stressing situations that he places them, such as trying to be effective against very large ballistic missile launches.

[Deleted.]

Senator **Schmitt**. Has the funding for the project office in this area been broken loose? Is that now an active project office?

Dr. **Cooper**. Yes. The Space Division has created——

Senator **Schmitt**. I know it has been created, but there has been some holdup on release of the funds for the program, the program planning activity that the Congress asked to be——

Dr. **DeLauer**. We focused on this whole question with Major General Lamberson of Bob's office.

Dr. **Cooper**. The problem with the funds has to do with question of appropriation and authorization, which we hope to get settled next week. If we do, we will go forward rapidly with the expenditure of those funds.

Senator **Schmitt**. Gentlemen, I wish we could continue, and we may have to at a separate time. Let us review the testimony and comments and get some answers to the questions for the record, and see if we need to meet again. I appreciate it very much.

Dr. **DeLauer**. Mr. Chairman, we will come back any time to talk about our and the Department's favorite subject.

Senator **Schmitt**. I was going to say, if you believe that I will sell you some land on the Moon.

Dr. **DeLauer**. It is all a matter of priorities.

[The statement follows:]

Statement of Dr. Richard D. DeLauer, Under Secretary of Defense for Research and Engineering

INTRODUCTION

Mr. Chairman and members of the subcommittee, I am pleased to have this opportunity to appear before you this morning to review the space and aeronautics activities of the department of defense. I plan to place special emphasis on department of defense space and aeronautics activities in which we work cooperatively with the national aeronautics and space administration (NASA). In order to provide perspective for these programs, I will briefly discuss recent Soviet activities in space.

SOVIET SPACE ACTIVITIES

Soviet space activities continued at a high launch rate indicative of an expansion of capabilities in 1981. The Soviets attempted 100 launches—more than the 89 launches each in 1979 and 1980—and placed 124 payloads into orbit, exceeding the previous record of 118 set in 1978. We expect this high rate to continue through the 1980s with the advent of new systems and capabilities. Development continues on new space boosters, one in the saturn V class, and large permanently manned space stations and complexes. Soviet military space capabilities include an antisatellite system; ever expanding communication relay satellite systems to support Soviet ground, sea and air forces; and various satellite networks for navigation and meteorology. A significant feature of the Soviet program and one which has considerable military potential, is their manned program. This program consists of a space station and a space station module. The trends and momentum of the Soviet Space program for 1981, as for the past 25 years, reflect a commitment to develop space capabilities that enhance and project military power. Now let me discuss some selected highlights and noteworthy developments during 1981.

Earth resources photography was accomplished by *seven separate erpho missions in 1981.*

Salyut 6, a 42,000 pound space station, completed four years in orbit on 29 September 1981 and remains in orbit. Two cosmonauts, ferried on an improved Soyuz (Soyuz T-4) performed a 75-day mission beginning 12 March 1981. They were visited by two more missions, Soyuz-39 and Soyuz-40, with one Mongolian and one Romanian crew member aboard respectively. Progress 12 provided supplies, repair parts, and propellants to the space station. On June 19, 1981 the Soviets docked Cosmos

1267 to Salyut 6. This test was described as a test of rendevous and docking and subsequent dynamics of two large space stations. According to the Soviets, Cosmos 1267-type vehicles will be used in the future as space station modules, each carrying equipment required for a particular mission. The events of 1981 certainly portend the advent of a new modular space station for the Soviets and move them well along the way towards the goal of a large permanently manned space station.

The Soviets launched four Molniya 1 and four Molniya 3 spacecraft in 1981 to maintain the communications satellite networks. They also successfully launched three Raduga geostationary communications satellites to provide civil and military communications relay. An Ekran satellite was launched to provide television broadcasts to far East regions. The Soviets also registered addtional satellites for deployment at geostationary altitudes in the 1980's, including two new geostationary data relay networks for the mid-1980's to provide data transmission to ground stations from low earth orbiting satellites via the geostationary relay spacecraft.

Meteorological satellite networks were maintained with three launches. The Soviets expanded earth resources data collection capabilities with oceanographic satellites to collect and relay buoy data from the seas.

The Soviets launched two Venus probes, Venera 13 and Venera 14, in October and November respectively. Each probe included a vehicle for descent to the surface of Venus while the primary vehicle performed a fly-by. Both probes successfully performed their missions durung the first week of March 1982. Four additional scientific satellites were orbited in cooperation with several countries for a variety of space exploration missions.

DEPARTMENT OF DEFENSE SPACE ACTIVITIES

Let me turn now to our own activities. Space activities of the Department of Defense are continuing to expand maintaining the trend of the past few years. Our military forces are becoming increasingly dependent upon space capabilities for communications, navigation, weather, and surveillance. As a result of space based capabilities, we find our forces are becoming more effective in achieving their assigned tasks. To ensure that our space assets can support our military forces in the event of war, we are improving the survivability of future space systems. In fiscal year 1983 we have requested $8.5 billion for the Department of Defense space programs. This represents a real growth of 20 percent relative to the $6.4 billion appropriated in fiscal year 1982. Table I provides a breakout of these funds among our major programs.

Space transportation system

Truly significant space accomplishments of this past year were the successful flights of the space shuttle Columbia. Never before has a spacecraft demonstrated the capability to fly a second mission. This historic precedent marks a major event in the exploitation of space. No longer will space be only a place for experiments and operational platforms whose reliability relies exclusively on autonomous systems. The space shuttle provides the key for a sustained presence in space, as a working environment. The capability to deploy, retrieve, service, and repair operational platforms is at hand. These capabilities, when coupled with the shuttle's larger volume and payload capabilities, portend a transformation in our use of space. The emphasis now shifts from getting there to working and exploiting the space environment.

NASA has taken the lead in the development of the shuttle, as you are aware. We in the DOD have made a strong commitment to exploit the shuttle and its associated technologies in our future space planning, and we look forward to the routine operational availability of shuttle to enable full consideration of its unique capabilities to enhance our space operations. In addition, we have accepted responsibility for the development and operation of the shuttle launch site at Vandenberg Air Force Base for polar orbiting missions, for the development and production of the inertial upper stage (IUS) for use on both civil and DOD space missions, and the development of a number of shuttle related operational capabilities which will enable the DOD to fully exploit the shuttle. We are also providing 42 active duty military personnel as astronauts. When coupled with the four retired military astronauts, we observe that over 50 percent of the active astronaut cadre of 81 are from the DOD.

TABLE I.—DOD SPACE AND SPACE-RELATED PROGRAMS

[Dollars in millions]

Program	Fiscal year—		
	1981	1982	1983
Mission oriented:			
Navigation	166.9	224.5	291.3
Communications	687.6	979.7	1,352.2
Warning	265.6	563.2	714.1
Mapping/Charting/Geodesy	11.6	29.2	53.1
Weather	86.5	114.3	235.9
Vehicle development	758.5	863.8	1110.4
Space ground support [1]	315.2	433.4	557.6
Supporting R. & D.[2]	586.1	755.2	972.5
General support [3]	1,919.1	2,399.0	3,164.6
Total	4,797.1	6,362.3	8,451.7

[1] Includes range support, instrumentation, ground based satellite detection, tracking and control.

[2] Includes research, exploratory and advanced development.

[3] Includes support organizations as well as general operational support.

We believe that the present Space Shuttle orbiter production schedule is adequate to meet the projected requirements until the planned rate of twent-four (24) launches per year is reached in fiscal year 1988. However, there is concern over the adequacy of a four orbiter fleet. I believe that it is in the national interest to maintain the production capability for additional orbiters until the ultimate fleet size is determined. I believe this is best achieved by continuing with production of the fifth orbiter, and I support NASA's efforts to obtain funding for this endeavor.

Mixed fleet

Both NASA and the DOD are investigating launch vehicle concepts to supplement our primary launch vehicle, the Space Shuttle. One concept under consideration is the so-called "big dumb booster", or SRB-X, that uses one or three solid rocket boosters, plus upper stages, to orbit up to 100,000 pounds. Another concept is the "in-line" launcher concept that uses a module with one or two main engines placed under the Shuttle external tank and a large cargo placed atop the tank. These concepts are of interest because they would permit operation of a mixed fleet of space launchers that would make broader use of Shuttle systems but not always require the Shuttle orbiters which may not be able to meet all future demands for space transportation.

The Air Force is studying several vehicle concepts. New concepts and advanced technology designs will be studied under a program called the advanced military spaceflight capability. Primarily, we are looking toward a vehicle that could provide a significant increase in unique military capabilities including survivability. Emphasis is being given to such requirements as on-demand launch, use of conventional airfields, military mission capability, etc. The Air Force Space Division has initiated an effort to identify requirements, to determine what systems will be necessary, and to pinpoint specific technology which will be needed to support development of these systems.

As military data from space has become more essential, the requirement for a more responsive launch capability has become more critical.

Quick reaction launch, survivable launch, and reusable aerodynamic space vehicles are examples of concepts which have been proposed to meet this need. Our proposed effort for the advanced military spaceflight capability (AMSC) programs includes research in those technologies which are critical to, and common to, the various AMSC vehicle concepts.

We believe that the Nation needs an additional capability to complement the IUS capabilities and provide us an available option for higher performance in the future. A thorough assessment of the options which could provide that capability were examined last month. However, all the affordable available options resulted in an unacceptable level of risk for our defense launch capability. As a part of this assessment, we investigated Centaur and found that it would not provide for the potential defense payload requirements. We are therefore proceeding with NASA to develop a higher energy, second generation upper stage for future use.

We are also continuing work on the new Consolidated Space Operations Center (CSOC). For management, operational, and economic efficiencies, CSOC combines two major space missions for DOD: Satellite control and Space Shuttle flight planning, readiness and command/control. In the role of satellite control, CSOC will enhance our operational capabilities by providing greater mission responsiveness. The Satellite Test Center and CSOC will provide mutual emergency backup for mission essential functions should outages occur at either center. In its other role, CSOC will directly control DOD Shuttle missions and enhance protection of national security information. Design of the satellite and Shuttle control systems is underway and construction will start in 1983. Satellite operations will commence in late 1986 with CSOC functioning as an integral part of our worldwide satellite control network. Shuttle missions will be controlled from the CSOC starting in late 1987. CSOC will have a unique role in military space operations as we extend the military applications of the Shuttle.

In summary, we are working closely with NASA in efforts to define our aggregate national needs for space transportation.

Space operations center (space station)

The space operations center is a concept for a planned Shuttle-serviced, continuously manned facility initially in low-earth orbit. As envisioned by NASA, the space station would provide for the development, utilization and subsequent growth of orbital science and applications capabilities and support orbital operations such as the in-orbit assembly, launch, recovery, and servicing of manned and unmanned spacecraft; the construction, checkout, and transfer to operational orbit of large, complex space systems; and the tending of co-orbiting, free-flying satellites and platforms. It would also provide continuing development of the capability to conduct operations in space with progressively less dependence on earth for control and resupply.

To support its human occupants, the space station would contain a habitation module incorporating a command center; crew quarters; food preparation, hygiene, and waste management facilities; exercise and recreation equipment; and a health maintenance facility with a small laboratory. A fully operational space station would require additional elements such as a logistics module, a flight support facility for servicing upper stages and co-orbiting satellites, a construction facility for fabricating large space systems, a propellant depot for storing propellants for reusable upper stages, and various research modules for scientific investigation.

The DOD is working closely with NASA in the definition of requirements for a space station. There are many potential military missions such as C3i, surveillance, on-orbit servicing and maintenance of DOD satellites, R.&D. etc., that could possibly be performed from a manned space station. Our initial activity must be examination of the potential utility and cost-effectiveness of a space station to satisfy national security needs, pursuant to a determination of the extent of DOD support for NASA's program.

Space weapons

The increasing capabilities of military space systems and the operating forces' reliance on them mark military satellites as attractive targets and underscores the importance of free access to space for our national systems. The Soviet Union's deployment of an operational antisatellite system demonstrates their understanding of that situation and provides additional rationale for DOD consideration of the role of space weapons. We must develop the means to deter an enemy from using antisatellite weapons against our military satellites. Furthermore, if deterrence fails, we must be able to protect our satellites using, if necessary, active satellite defense weapons.

In response to a congressional request, DOD conducted a major review of the potential of space-based laser weapons which is documented in the 15 May 1981 DOD report to the Congress on space laser weapons. We concluded that space-based lasers offer military potential in a number of applications, but we are uncertain of our ability to predict with confidence their ultimate utility. Accordingly, we have established a $50M/year augmentation to our space based laser program beginning in fiscal year 1983, to more aggressively pursue resolution of uncertainties. The program will be initiated in fiscal year 1982 using funds specifically appropriated (but not authorized) by the Congress to begin the work. The DARPA portion of the additional funding will be used to accelerate technology development for short wavelength lasers which, if successful, have the potential of permitting the use of smaller diameter optics for an equivalent ability to focus the laser spot onto a target at long range. The Air Force portion of the additional funding will be used to address overall system and utility issues, to include survivability, total system architecture (e.g., surveillance, command and control), and Soviet ability to harden potential targets.

Space-based laser communications

A joint DARPA/Navy submarine laser communications (SLC) program is developing the technology to communicate from space, using blue-green laser light, to submarines at operational depths with minimal impact on their natural covertness and flexibility. Early tactical SLC capabilities are expected from an airborne system to limited areas. A space-based SLC system might provide for global coverage, survivability, and flexibility in both tactical and strategic operations. The SLC program is investigating systems concepts and advancing device and optics technology for communication to submarines at operating depths that would use laser beams from a satellite in the blue-green spectrum. In early 1981 technology advances in optical receivers permitted an experimental verification of SLC communications from aircraft through clouds and water to a submerged submarine. While not an operational demonstration, this test served to validate performance predictions.

Satellite communications

In the area of military satellite communications systems, we have spent a year and a half on a joint effort with all the services and agencies involved to define a new MILSATCOM architecture. This architecture relates combat and combat support needs to near, mid, and far term MILSATCOM systems in the presence of the ever growing Soviet threat. The heart of the architecture is MILSTAR, a system to provide survivable and enduring, jam-resistant communications to small and mobile terminals of the strategic and tactical forces. A joint program office has been established at the Air Force's space division where system definition efforts are under way. We anticipate the DSCS III satellite program will continue to provide its unique and vital services throughout the 1980s. We are asking for funds to continue the acquisition of three additional FLTSATCOM satellites to ensure we do not have a strategic communications gap until the MILSTAR system is sufficiently operational.

We will continue the LEASAT program to support our tactical forces and general purpose mobile users. We intend to pursue a vigorous R&D program to ensure our MILSATCOM systems have the necessary attributes to support our war fighting forces throughout the spectrum of conflict. MILSATCOM is composed of elements supporting strategic, tactical, and long-haul communication users.

AFSATCOM was conceived as an evolutionary SATCOM system to provide the national command authorities (NCA) and CINCS with worldwide secure, survivable communications for command and control of the nuclear capable forces. The initial phase, AFSATCOM I, achieved IOC in 1979 and provides essentially worldwide coverage with a modest anti-jam capability. The space segment consists of transponders on polar-orbiting satellite data system satellites, geostationary FLTSATCOM satellites and other host satellites. The earth segment consists of a family of terminals installed in the large command centers serving the NCA and the CINCS, Bomber/Reconnaissance/Command Post/Tacamo Aircraft, and the ICBM launch control centers. The system handles low-speed teletype messages for emergency action message dissemination, NCA/CINC internetting, force direction, and force reportback.

The AFSATCOM I system is being augmented by the incorporation of single-channel transponders (SCT) into the DSCS III spacecraft. Increased jam resistance is achieved through improved modulation techniques and the use of higher uplink frequencies. Survivability against physical attack is also enhanced through proliferation.

While the AFSATCOM I UHF system represents a significant increase in capability insofar as connectivity, coverage and reliability are concerned, an increasing threat dictates that vulnerabilities in the current system be eliminated. MILSTAR is the next generation MILSATCOM system which will provide a survivable and enduring warfighting communications capability into the next century.

The Defense Satellite Communication System (DSCS) is a high capacity, superhigh frequency (SHF) system to satisfy the unique and vital national security communications requirements for worldwide military command and control, intelligence information transfer and crisis management. The DSCS supports telecommunications needs of the Worldwide Military Command and Control System (WWMCCS), the National Command Authorities (NCA), the Ground Mobile Forces (GMF), the Diplomatic Telecommunications System (DTS), the Defense Communications System (DCS), and selected allies.

In December 1976, the Defense Systems Acquisition Review Council (DSARC) authorized full scale development of the DSCS III satellite. In February 1977, a contract was awarded to complete satellite design, develop, test and support the launch of two DSCS III demonstration flight satellites (DFS); develop a refurbishable qualification model satellite; and conduct on-orbit demonstrations. Also, subsystems engineering development model satellite configuration control elements (SCCE), which allow control of DSCS III satellites are under development. The launch of the first DSCS III paired with a DSCS II satellite is planned for September 1982 on a Titan III (34)D/IUS launch vehicle. A second DSCS III will be available for launch in late 1983 also paired with a DSCS II satellite. A DEPSECDEF decision to proceed with full production of two DSCS III satellites in fiscal year 1982 was made in January 1982. The fiscal year 1983 request contains funding for two additional DSCS III spacecraft.

DSCS terminal procurement continues on schedule. The last of the 18 large AN/MSC-78 terminals equipped with 60-foot parabolic antennas became operational in March 1978. In mid-1978, new contracts were awarded for the medium terminal (MT) equipped with a 38-foot parabolic antenna and the AN/USC-28 anti-jam communications equipment. In September 1979, the Army awarded a contract for 225 ground mobile forces terminals to support Army tactical operations. These terminals will be equipped with an anti-jam modem and are highly transportable. The contract for procurement of 33 transportable jam resistant secure communications terminals was awarded in 1981. These terminals will provide a sensor data network, fixed and executing command networks and secure voice/graphics conferencing for tactical warning and attack assessment (TW/AA) and command and control functions.

FLTSATCOM is a UHF satellite communications system which significantly improves naval communications to meet the needs of the fleet in the 1980's. The system consists of four geostationary satellites now on orbit which provide virtually worldwide coverage for fleet operations. The Navy is developing a family of information exchange subsystems to provide automated traffic and access control over the communications channels. Advanced control equipment is being developed to implement demand assigned multiple access (DAMA) techniques to improve channel utilization. All ships are now equipped to receive the FLTSATCOM fleet broadcast and over 340 vessels have a transmit capability.

As a result of damage incurred during launch, satellite number five (planned as an on-orbit spare) is operationally unusable. To provide continuity of service for both FLTSAT and AFSAT users, three additional satellites are being procured to be available for launch beginning in 1985. A small EHF FLTSAT test package will be deployed on FLTSATS 7 and possibly 8 to reduce technical risk and to provide a means to conduct technical and operational evaluation testing of engineering development EHF satellite terminals.

In response to congressional direction, DOD issued a contract in October 1978 for a leased satellite system (LEASAT) to follow the FLTSATCOM program. A four operational satellite constellation is planned to provide worldwide leased UHF satellite service. System IOC is linked to the Space Shuttle schedule since the spacecraft configuration is incompatible with expendable launch vehicle dimensional constraints. The capacity of the leased satellite system is substantially less than that of FLTSATCOM and has no jam resistance. The reduced capacity was necessary in order to provide a simple satellite design that could be obtained by leasing. LEASAT service will begin in 1984 and could extend into the 1990's.

The MILSTAR system is a new, highly survivable and enduring satellite communications (SATCOM) system. This new system will provide high capacity, worldwide, jam-resistant communications for our strategic and tactical forces. Principal users of MILSTAR will be the strategic nuclear-capable forces, the Navy, and tactical ground mobile forces of the Army, the Marine Corps, and the Air Force. Missions to be supported include emergency action message (EAM) dissemination, strategic force management, CINC internetting, fleet operations, and tactical communications for mobile forces.

The baseline MILSTAR constellation will consist of five geosynchronous satellites (four operational and one spare) and three polar-orbit satellites. The seven operational MILSTAR satellites will provide communications service to all areas of the Earth exclusive of the south polar region. UHF channels will be used to ease transition and provide continuity of service with terminals now serving strategic and selected tactical forces. The UHF channels will be interconnected with the EHF channels to enable consolidation of all MILSTAR crosslink and downlink information.

The terminal segment of the MILSTAR system consists of terminals located on aircraft, ships, submarines, jeeps, armored track vehicles, and at fixed terrestrial sites. There are two classes of EHF terminals: User communications terminals which provide communications capability only, and control element terminals which provide satellite payload and system control capabilities as well as communications capability.

MILSTAR design will incorporate both electronic and physical survivability features to counter jamming and ASAT threats postulated for the 1980's and 1990's.

The system definition and design phase will conclude in October 1982. Funding to begin in the MILSTAR is included in the fiscal year 1983 budget request.

The NASA 30/20 GHz communications satellite effort, although being developed for a very different mission, does have frequencies adjacent to the MILSATCOM 30/20 GHz system. For that reason, the DOD does have some joint activity with NASA. For example, we are currently sharing the development of 20 GHz transmitting devices. The DOD will continue to pursue joint projects with NASA where it is in the best interest of both organizations to do so.

Meteorology

The defense meteorological satellite program (DMSP) supports DOD needs for weather information. Its operational requirements dictate the use of at least two satellites continuously in orbit, obtaining weather information from all points on the earth at least four times each day. Global weather data is stored on the satellites and later transmitted to the Air Force global weather central or to the Navy fleet numerical oceanography center. Regional weather data is also transmitted in real time to transportable read-out stations at key locations worldwide to support Army, Navy and Air Force tactical operations.

Navigation

The DOD is continuing the development of the NAVSTARY global positioning system (GPS) to satisfy the military need for information on the lccation of force elements. Navstar GPS will provide users with precise position information on a 24-hour, global basis under all weather and visibility conditions, This capability will significantly enhance the mission effectiveness of all us military forces, in addition to its primary function of improving us and allied military forces' weapon delivery and target destruction capabilities, GPS has the potential to provide unique positioning and navigation services to civil and commercial interests on a worldwide basis. GPS satellities will also play another extremely vital defense role by carrying the integrated operational nuclear detection system (IONDS) payloads. Ionds will provide real-time strike and damage assessment information, thereby enhancing strategic force management.

In virtually all tests to date the GPS prototype equipments have met or exceeded expectations. During 1982, therefore, we are finalizing our plans to initiate procurement of the operational satellites and continuing full scale development of both the ground control segment and the user equipment. Continuation of our ongoing efforts will lead to the establishment of a worldwide, highly accurate, three-dimensional positioning and navigation capability by 1988.

Ocean surface surveillance and targeting

Continuing evaluation of the threat and fleet operations has shown that none of the Navy's operational surveillance systems provides the full range and depth of information required by tactical commanders. In the mid to late 1970s, the Navy examined the possibility of filling this need with an ocean surveillance active radar satellite. System validation studies proved the value and technical feasibility of the concept; however, the proposed radar satellite provided no capability to detect and tract high-speed aircraft. Given a constrained budget and the system's projected high development cost but relatively low tactical utility, the Navy decided not to proceed to advanced development. Nevertheless, the Navy recognized the potential of an active space-based sensor to satisfy its offensive and defensive needs. Accordingly, a detailed assessment of needs and system alternatives was undertaken, leading to initiation of concept exploration studies for the integrated tactical surveillance system (ITSS) in November 1980. The concept exploration studies will lead to more explicit needs definition and will provide the information on which the Navy will base decisions on the future development of ITSS.

ITSS, as an evolving system, will be built on several existing programs. In those cases where existing capabilities are found to be deficient, upgrades and/or new system developments will be initiated. Upgrades will provide near-term system improvements while needed new capabilities are under development.

A key issue in ITSS concept exploration is whether there is need for development of an active space-based sensor. Passive sensors (e.g., electro optical) do not provide worldwide, all-weather, day-night surveillance. An active sensor of some type is an essential element of the ITSS and can potentially satisfy more than just Navy requirements. During concept exploration, the Navy will validate the need for an active sensor and evaluate alternative systems.

The other services are involved in the ITSS program through participation in monthly working level meetings to discuss ITSS development issues and quarterly summary reviews of the concept exploration studies. The Air Force applied funds to the concept studies to examine various aspects of ITSS applicability to satisfying their CONUS atmospheric tactical warning requirements.

The concept exploration studies were completed in February 1982 and are being evaluated by the Navy. A DSARC–I tentatively is scheduled for the June 1982 timeframe. Because of a desire to examine the ITSS concept more closely before proceeding to advanced development, Congress limited the program's funds to $12.3 million in fiscal year 1982, to allow completion of the concept exploration studies. The Navy budget requests $16.9 million for ITSS in 1983

Strategic defense systems

The defense support program (DSP) is one of the key elements of the U.S. defense posture. The system utilizes satellites at synchronous orbit. In fiscal year 1982 we initiated the procurement of long lead items for additional satellites to maintain the space segment. The fiscal year 1983 budget requests funds for the acquisition of two DSP satellites.

The development of the integrated operational nudets detection system (IONDS) is being pursued by the air force. IONDS is being developed to provide a capability to detect, locate and report in near real time nuclear detonations on a global basis. The plan for the program is to provide funds to place sensors on navstar global positioning system (GPS) satellites and for ground readout and display equipment for several users, such as the national command authorities, commanders of theaters and unified/specified commands, and other other users as may be designated.

Supporting science and technology

The DOD is investigating a wide range of space technology to maintain our present lead, estimated to be 5 to 10 years, over the Soviets in selected areas. Many of these technology base efforts, such as lasers and communications, are highlighted elsewhere in this statement. The following are some of the others which offer considerable promise.

Several programs related to missile surveillance technology and developing senors and collecting background data for application of infrared (IR) technology to surveillance and warning missions. In missile surveillance technology, new infrared measurement hardware was purchased during 1981 to improve the accuracy and effectiveness. Rocket and balloon flights are planned for 1982, infrared data on earth backgrounds and rocket engine plumes will provide a major contribution to system design considerations for space-based missile surveillance system. In space surveillance technology, the space infrared sensor, precursor to a space-based surveillance system, was completed and awaits a decision to launch. Two IR background measurement probes were launched successfully in 1981.

The Navy, air force and defense advanced research projects agency (DARPA) in 1981 accelerated development of critical technologies supporting advanced concepts and technology for strategic and tactical surveillance from space. Programs possibly leading to demonstration of these technologies in a system level proof-of-concept experiment for improved mission performance are continuing.

Development of surveillance technology for infrared mosaic detector arrays, onboard signal processing, cryogenic refrigerators large optics, and structures continued in 1981. A new generation of detector arrays, physically integrated with preprocessing electronics in a planar configuration, was tested. The breadboard model of a lightweight, large-data-capacity, onboard processor was successfully demonstrated against real target and background data from the hi-camp airborne imaging spectroradiometer. Quantity production of teal ruby mosaic chips using the fully automated cryogenic test set was performance-qualified. Darpa completed the system requirements review of the advanced sensor demonstration program to demonstrate advanced surveillance missions and the technology base developed to support them. Technology development continued for key components and concepts for space-based radar, including transceiver modules, large lightweight phased array antenna structures, and onboard signal processing components. Darpa continued design and analysis for the talon gold experiment to develop space technologies for precision acquisition, tracking and pointing at long range.

The cryogenic infrared radiance instrumentation for shuttle (CIRRIS) will examine earth limb/atmospheric backgrounds for an increasing number of systems applications using infrared technology as well as studying a number of shuttle payload contamination issues. The CIRRIS payload was integrated with the shuttle experiments support system in 1981.

Advanced microwave technology on miniature, low cost radar transceiver modules using integrated circuit technology is being pursued. Low cost/weight and high efficiency of the modules are key factors in feasibility for use in space-borne radars as well as a veriety of other phased array radar and communication applications in airborne and surface systems. A silicon-on-sapphire mosfet power amplifier has been demonstrated. Improved designs for low noise amplifiers, phase shifters and passive transmit/receive switches will soon be evaluated. Fabrication and testing of fully integrated modules are planned for late-1982. Similar critical components in gallium arsenide technology have been demonstrated and improved designs will be evaluated in 1982. Work has continued to demonstrate antenna pattern performance of candidate space-borne, phased-array radar membrane structures.

DOD AERONAUTICS ACTIVITIES

I would now like to turn our discussion to activities in the aeronautics area. For fiscal year 1983, the Department of Defense, development, test and evaluation budget for aircraft and related equipment is approximately 3.7 billion dollars. Of this amount, 357 million dollars is devoted to aeronautics technology development which is that portion of our program most closely aligned to NASA activities. I would now like to duscuss some of the more important programs in this area.

Last year we reported that the Air Force had just initiated flight tests on a modified F-15B test bed aircraft to demonstrate the concept of integrated flight-fire control. Through this integration of the aircraft flight control, fire control and weapon systems, the pilot is able to fly to a predetermined position for optimum weapon launch for either air-to-air or air-to-ground delivery. Combat capability is enhanced, not only through increased weapon delivery accuracy, but also by the ability to fly highly evasive maneuvers in the terminal delivery area, thereby greatly increasing aircraft survivabilty. The current flight test program has been delayed due to damage to the one-of-a-kind sensor POD used in this concept. The POD has now been repaired and the program is back on track, with the initial testing planned to be completed by April of this year. While we have not yet been able to obtain statistically significant data from this program, qualitative pilot comments obtained from the 33 flights to date indicate great enthusiasm for the system and a general overall assessment that this concept will definitely enhance combat capability.

In a related joint Air Force/NASA program on advanced fighter technology integration, an F-16 aircraft is being modified to provide the capability to independently control aircraft translational and rotational degrees of freedom about each axis. This results in unique maneuvering capabilities. For example, the aircraft will be able to move up, down or sideways, without rotating, or it can be made to rotate about any axis, or maneuver employing any combinations of these motions. Coupling these unique maneuver capabilities with modern aircraft flight control concepts results in significant improvements in weapon delivery accuracy and increased survivability. Due to problems encountered in developing and validating the flight control software, first flight of the F-16 test bed has been delayed until April of this year.

The defense advanced research projects agency is well underway in developing the forward swept wing demonstrator aircraft, designated the X-29. Grumman aerospace corporation is designing and fabricating two X-29 aircraft to demonstrate several aspects of forward swept wing configurations including low speed handling qualities, spin resistance, canard aerodynamics and relaxed static stability. The primary reason forward swept wing designs are not used today is due to a structural/aerodynamic interaction that requires an extremely stiff wing which would be excessively heavy using conventional materials. The current DARPA program will validate the use of advanced composite structures to solve the wing weight problem. Flight tests of the X-29 which will be conducted by NASA at the Dryden Flight Research Center, are scheduled for early fiscal year 1984.

The joint Air Force/NASA mission adaptive wing program, seeks to exploit aerodyamic advantages obtained through the application of new materials. In this program we are developing a smooth contour variable camber wing. Current aircraft use a single wing contour to accommodate flight at best cruise, low altitude dash, supersonic cruise, maneuver and loiter conditions over a wide range of aircraft loadings. In this concept, the wing controur will automatically change in flight to attain peak aerodynamic efficiency throughout the flight envelope, resulting in increased range and maneuverability. First flight of the mission adaptive wing on a modified F-111 test bed aircraft is scheduled for December of this year at the Dryden Flight Research Center.

Last year we reported that programs have been initiated to examine the utility and effectiveness of metal-matrix composite materials for aircraft. The results of these early investigations revealed the vast military application potential for both filamentary and particulate reinforced metals such as aluminum, magnesium and titanium. To capitalize on these potential military applications, several major demonstration projects have been initiated. Under an Air Force contract, Lockheed Georgia Company will design, fabricate and test A C-5 size aircraft wing box subcomponent of metal-matrix composite. This component will be 25 feet long and will be designed to withstand loadings in the vicinity of the outboard wind pylon. This program will undertake to demonstrate the largest metal-matrix composite structure ever built. Our interest in metal-matrix composites stems from the fact that while the structual performance characteristics are similar to those of non-metallic composites, they can be fabricated with existing metal-working tools and machinery and therefore will not require large capital investment in new production facilities.

Based on the successful exploratory development program we reported on last year in metal-matrix composite reinforced helicopter transmissions which led to appreciable reductions in the sound and vibration intensity, the army has contracted with Boeing vertol to design, fabricate and test six full scale, integrally reinforced metal-matrix composite nose gear box assemblies for the CH-47 forward transmission housing. This new program will be followed-up with a manufacturing technology program to develop production tooling for these integrally reinforced metal matrix composite transmission housings.

Over the past several years we have made significant gains in improving engine performance, while striving to reduce development risk and costs, maintenance costs and acquisition costs of a broad spectrum of aircraft propulsion systems. In our joint technology demonstrator engine program we have developed a large fighter engine configuration with a potential for a 15 percent increase. In thrust to weight ratio, a 15 percent reduction in fuel consumption and 24 percent in the number of parts compared to the current F-100 engine. This variable bypass ratio configuration has recently completed over 120 hours of altitude and cyclic testing as a step toward improving our understanding of the engine environment and our ability to predict durability.

We have also realized substantial improvements in shaft engines for helicopter applications. In this regard, we have recently completed evaluation of two competitive 800-horsepower turbo-shaft engines which demonstrated a 20 percent reduction in fuel consumption, a 30 percent increase in specific horsepower, and a 50 percent reduction in vulnerable area compard to the pt-6 engine. These configurations have also demonstrated sufficient durability to allow full-scale development to be undertaken with confidence.

I would now like to briefly discuss some of our advanced rotor craft programs. Testing has continued on the XV-15 tilt rotor research aircraft during this past year. Through this joint Army, Navy, and NASA sponsored program, the XV-15 has been flown to the limits of the design envelope. Our current efforts are devoted to operational type testing for all three military services, including shipboard trials with the Navy. The tilt rotor concept is a prime candidate for the joint services vertical lift aircraft development program known also as the JVX. This program is oriented toward developing a new aircraft to perform a variety of missions in all thre services including Marine Corps assault and carrier base antisubmarine warfare for the Navy; search and rescue for the Air Force; and, special electronic mission aircraft for the Army.

As we reported last year, 1982 was to be our last year of testing on the advanced blade concept or ABC helicopter. The ABC features two very rigid coaxial counter rotating rotors and auxiliary jet engines to provide high speed forward thrust. The ABC has established an unofficial world speed record for rotary wing aircraft by attaining speeds of 240 knots in level flight, and 263 knots in a slight dive. During this past year, the ABC was flown through a variety of operational tests at the Army aviation center at Fort Rucker Alabama, both as a pure helicopter and with auxiliary engines. We consider that ABC technology is developed and a candidate for future helicopter applications such as the Army LHX which is planned to enter full scale engineering development in 1986.

I would now like briefly to discuss the national aeronautics facilities program which was established jointly by DOD and NASA some years ago.

The Aero Propulsion System Test Facility (ASTF) being constructed by the Air Force at Tullahoma, Tennessee represents the DOD portion of the national program. This facility is designed to support the economical development of advanced engines for fighter and large strategic transport and bomber aircraft. In addition it will provide the only capability in the free world that can stimulate dynamically and realistically most of the operating envelopes for large aircraft engines and engine inlet combinations. Due to equipment interface problems, requiring considerable design changes, we have encountered construction delays and cost growth in the ASTF project. However, we have now identified all remaining changes and are confident that the facility will be operational by 1984.

We have a keen interest in the National Transonic Facility (NTF) being develoed at the NASA Langley research center. We have completed coordination of the initial operating plan with NASA. When this facility begins high reynolds number testing next year, it will mark the beginning of a new era in aeronautical research.

Finally, I would like to note that modifications to the full scale 40 times 80 foot wind tunnel at Ames research center are of particular interest to DOD. Planned new helicopter and V/Stol aircraft developments such as the LHX and the JVX will benefit significantly from the availability of the larger test section and the increased tunnel power provided by these modifications.

MANAGEMENT OF SPACE AND AERONAUTICS PROGRAM

Due to the similar nature of the work performed by NASA and DOD, it is clearly in our mutual best interest to cooperate extensively in many endeavors. This cooperation manifests itself primarily through the many jointly-manned research and operational facilities which conduct aeronautics and space technology research. In addition, senior management maintains oversight for our common interests through the aeronautics and astronautics coordinating board (AACB). The ACCB, co-chaired by Dr. Hans Mark, deputy administrator of NASA, and myself, meets periodically to review programs of mutual interest and develop plans for our future programs. The board met just this past month to review the status of the space transportation system and the technical impact of the planned reductions in the NASA aeronautics budget. Technical interchange is assured through the many standing panels of the AACB along with numerous working groups which are formed to address specific issues.

We are participating with Dr. Keyworth, Presidential Science Advisor, in the study sponsored by his office on U.S. Aeronautics Research Policy for the 1980's and 1990's. I fully support this activity and I have nominated Dr. Robert S. Cooper, director of DARPA to be the DOD member of the senior executive review panel. In addition, several members of my staff, as well as personnel from all three military services are supporting the study through membership on the working group. I am certain that this will be a significant and far reaching activity, with policy implications which could have major impact on the future of aeronautics research in the United States.

In addition, the DOD has undertaken an internal review of its space policy. This was felt to be necessary in order for the DOD to effectively plan the future course for the military use of space. This department-wide study is chaired by the USD(P) and is intended to produce a comprehensive DOD-space policy to guide the conduct of the space activities of the department. The DOD space policy will also serve as a frame of reference for the department to address some of the issues being reviewed in the national space policy review also under the auspices of the Office of Science and Technology Policy.

In establishing the basis for the new DOD space policy, careful consideration is being given to treaties and international agreements impacting the use of outer space and the body of existing U.S. space laws and policy.

The DOD space policy study is in its final stages and we anticipate recommending the policy to the Secretary of Defense before the end of April.

The centralizing management of space activities within the DOD, has been discussed for some time. Recently a bill has been introduced in the House (H.R. 5130) which directs the Secretary of the Air Force to report to Congress on the feasibility and desirability of establishing a separate command for space. Our organization for space has been evolving fairly rapidly over the past four years. Within the Office of the Secretary of Defense we have established the defense space operations committee. The Air Force has established a space operations steering committee; formed a new directorate of space within the Deputy Chief of Staff, Plans and Operations at Headquarters Air Force, and has designated the Deputy Commander for space operations at space division in Los Angeles. Within my office, I have asked Dr. Robert S. Cooper, Director of DARPA to act as the principal focus for review of space research and development across all mission areas. All these organizational changes were made to sharpen our focus for space activities and bring increase management attention to this important area. We will continue to evaluate organizational alternatives to effectively manage our space activities.

CONCLUDING REMARKS

As we move into the mid-1980s, this administration has drawn attention to the increasing rise in Soviet capabilities. This rise is not limited to the tactical and strategic warfare programs, but also is taking place in the research and development activities on which the space programs of the 1990s will be based. In order to meet the Soviet challenge, we in the executive branch must work with the Congress to ensure the continued superiority of our national technological capabilities.

I would note that continuing technological advancement in space is dependent on the availability of sufficient numbers of qualified scientists and engineers. The Department of Defense is currently looking into issues related to national shortages in specific scientific and engineering specialities in order to determine what impact national shortages, particularly in the engineering field, are having on our ability to recruit, retain and support scientific, engineering and technical personnel. Among the areas we are concerned about are:

Current shortages of Ph. D. engineers, particularly the estimated 10 percent faculty vacancy rate in our Nation's engineering schools;

The large number of foreign nationals taking advanced degrees as contrasted with the small number of U.S. citizens pursuing a graduate education;

The inadequacy of university facilities and equipment for teaching and research;

The quality of elementary and secondary education and our current ability to equip our youngsters to pursue the rigorous course of study demanded by scientific and engineering disciplines; and

The ability of the public sector, and particularly such agencies as Defense and NASA, to compete effectively for scarce scientific and engineering manpower when private sector salaries and other benefits outstrip those of the civil service by more than a factor of two in many cases.

Future advancement in science and technology cannot be made without first insuring that we have the people to make them.

Proper support for our national science and technology programs not only enables the development of systems we seek but also serves to engender interest and attract and retain the highly skilled personnel so vital to our national preeminence in astronautics and aeronautics.

Parochially speaking, I view this support as critical to our national security, but I also fully recognize its importance to civil applications.

I, therefore, encourage your full support for the space and aeronautics programs of both the DOD and NASA, recognizing our common goals in preserving U.S. technological excellence and the synergisms of our cooperative program in these endeavors.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. Could you describe for us in more detail your joint activities with NASA that are relevant to the MILSTAR 30/20 GHz system?

Answer. The MILSTAR program plans to use 44/20 Gigahertz technology to provide highly jam-resistant communications to strategic and tactical military users who utilize small mobile terminals operating at low data rates and low duty cycles. 30/10 Gigahertz technology is being proposed for future national users which utilize larger fixed terminals and operate at high data rates and high duty cycles. NASA is also planning a 30/20 Gigahertz program, but it is almost totally different than DOD's 30/20 program. The NASA program is designed to meet the needs of commercial domestic users which operate with fixed terminals operating at high data rates and low duty cycles.

The only commonality between the MILSTAR 44/20 effort, the potential DOD 30/20 GHz effort and the proposed NASA 30/20 GHz effort is the GHz downlinks. In this area, DOD and NASA have three cooperative efforts. One is for a 20 GHz TWT which has two modes of operation (7 and 75 watts). The second is a 20 GHz impact solid state amplifier which operates at 20 watts and the third is a 20 GHz FET solid state transmitter which operates at 6 watts output power.

RELATIVE CAPABILITIES OF U.S. AND SOVIET SPACE SYSTEMS

Question. Please compare the relative capabilities of the U.S. and the Soviet Union in these areas: photoreconnaissance, earth resources/geodetic, ocean reconnaissance, launch detection, and communications.

Answer. [Deleted.]

PHOTORECONNAISSANCE

U.S. photoreconnaissance capabilities are classified at a level which does not allow inclusion in this report. A description of U.S. capabilities in this area will be made available to appropriately cleared personnel if so desired.

EARTH RESOURCES/GEODETIC

The Soviets use a variety of vehicles to obtain earth resources data: [deleted].

U.S. geodetic and navigation satellites have contributed heavily in the definition of the improved world geodetic systems (WGS). Such systems define the figure of the earth, intercontinental tides, and the gravity field. The gravity field is determined by a combination of satellite tracking data and local gravity measurements. Satellite geodesy results and technology have been widely published in the open literature [deleted].

The U.S. nonmilitary space program has placed in orbit a variety of sensors to monitor earth resources. A series of satellite imaging devices passively obtain high fidelity images of the earth's surface in the visible wavelengths (from 0.5 + 0.75 micrometers) and infrared (0.8 to 13 micrometers) regions of the spectrum. The Environmental Satellite Service of NOAA provides a remarkable spectrum of products from the 27 environmental satellites in roughly 1000 km polar orbits and the 9 environmental satellites in geosynchronous polar orbits. NOAA can provide visible and infrared earth images with 1-8 km resolution of the entire globe. They also provide ocean and lake temperature data, ice location charts, ocean current analysis, river basin and regionl snow coverage and a variety of meteorological products.

LANDSAT is a space-based sensor system which provides high resolution visible and infrared images. Five LANDSAT satellites are planned and four have been launched in 570 nmi polar orbits. The LANDSAT satellite can cover the entire glove every 18 days or each hemisphere every 9 days. An important sensor on this satellite is the Multispectral Scanner System (MSS). The MSS acquires infrared images 115 miles on a side in four wavelength regions in the visible and near infrared regions (0.5–0.6, 0.6–0.7, 0.7–0.8, and 0.8–1.1 micrometer wavelengths). The first band emphasizes movement of water and locates shallow water area, the second band emphasizes cutural features; e.g., metropolitan areas, and the last two emphasizes vegetation, the boundary between land and water and land forms. A composite of the data from all bands produces a "false color" image which makes it possible to identify and characterize key features of the scene.

The DOD has specialized requirements for meteorological satellite data to provide for its worldwide responsibilities. The primary objective of the Defense Meteorological Satellite Program (DMSP) is to provide timely global visual and infrared cloud cover and other specialized meteorological data to the Air Force Global Weather central (AFGWC) in support of special strategic missions. The DMSP also provides direct read-out of local area weather data to fixed and mobile terminals throughout the world to support military operations.

The DMSP system consists of [deleted].

The Nimbus satellites are second-generation (following the early TIROS spacecraft) meteorological research and development spacecraft designed to serve as stabilized, earth-oriented platforms for the testing of advanced systems for sensing and collecting meteorological data.

The principal overall objective of the Geostationally Operational Environmental Satellite (GOES) program is to obtain near real-time data simultaneously from an entire hemisphere of the earth. More specifically, each of these satellites will provide day and night pictures of the Western Hemisphere of the earth (approximately each 30 minutes). These pictures can be provided more frequently if required.

Another function of these satellites is to receive environmental information from as many as 10,000 manned or unmanned data collection platforms. These data are then transmitted to appropriate groundbased receiving stations. In this way, hemisphere-wide, detailed meteorological data are made available in almost real time.

The GOES system is intended to be essentially a civilian, peacetime data gathering and distribution system. However, the data are available to the military as required. At present there are six geostationary meteorological satellites in orbit.

OCEAN RECONNAISSANCE

[Deleted.]

The U.S. Seasat, launched on 26 June 1978, carried a sensor for radar observation of the ocean surface [deleted]. It was active for only about 3.5 months. [Deleted.]

LAUNCH DETECTION

The Soviet launch detection [deleted].

COMMUNICATIONS

[Deleted.]

The United States because of its excellent internal terrestrial communications networks, its global deployment of forces and bases, and its many international activities, initially concentrated on the development of global trunk line communications for both military and commercial purposes. The satellite systems established in the mid and late 1960's provided increased capacity as well as additional flexibility and reliability in international communications. These systems have grown until now there exist global networks for fixed point commercial service (Intelsat), commercial maritime service (Marisat), military and diplomatic command and control and administrative services (DSCS), and military mobile terminal service FltSatCom/Gapfiller/AFSatCom). The military systems are strictly for military use, except for some official State Department and Presidential use of DSCS. The commercial Intelsat, while nominally entirely civilian, is used by the Department of Defense (DOD) for some routine voice circuits and alternative routing for some data circuits.

The Defense Satellite Communications System (DSCS) operational system consists of four active satellites approximately equally spaced in a geosynchronous orbit and two orbiting spares, plus a number of fixed and transportable terminals providing access to other communications media. Two satellites at a time are launched from the Eastern Test Range using a Titan IIIC booster. Later launches will utilize other boosters including the Titan 34 D/IUS and the Space Shuttle/IUS. Terminal locations and active links which use the two satellities are at 12° W and 175° E longitude. In 1980, the ground segment of the system grew to about 160 ground-based, airborne and ship-based terminals.

The Fleet Satellite Communications System (FltSatCom) system provides a worldwide operational communications network for the US Navy. It provides links for broadcasts to the entire fleet and for communications between ships and between ships and shore stations. Shore stations are able to communicate with selected aircraft. The AFSatCom system performs a similar function for the U.S. Air Force. AFSatCom connects ground and airborne command posts, and provides Commander in Chief links between the command posts and strategic aircraft. Certain Army mobile forces and some nonstrategic aircraft may also use a portion of the system for their communications links.

The FltSatcom system has four satellites and synchronous equatorial orbit. These four satellites provide coverage of the entire earth except for the polar regions.

The AFSatCom system uses a separate transponder system abroad the equatorial FltSatCom satellites. In addition, communication packages or the Satellite Data System (SDS) satellites provide coverage of the northern polar region. Newer, single channel transponders (SCT) will be deployed for emergency action messages (EAM) dissemination on the DSCS III satellites.

The Satellite Data System (SDS) carries payloads which supplement FltSatCom in meeting critical ultra high frequency (UHF) transpolar two-way, real-time communications needs for the strategic forces and provide an S-band relay capability for the AF Satellite Control Facility. It provides north polar communications from continental US (CONUS) locations.

[Deleted.]

The Leased Satellites (Leasat) system will provide a worldwide communication system for DOD during the 1983 and 1988 time period. Leasat is being developed as a direct successor to the FltSatCom system. It will be used primarily by the US Navy for interconnecting ships, submarines, aircraft, and shore stations. In addition, some non-nuclear Air Force mobile units will use the system.

The basic Leasat contract stipulates that the lessor will provide specified communication services for five years at each of four orbital locations.

The Lincoln Experimental Satellites (LES) are part of a program to develop communication satellite techniques. The current satellites, LES 8 and 9, operate with a variety of fixed and mobile terminals using both UHF and K-band (36–38 GHz) for uplinks and downlinks. A K-band crosslink between LES 8 and 9 is also being used.

Question. Do we have any indication of the U.S.S.R. offering their launch services commercially?

Answer. [Deleted.]

Question. What plans does this country have to counter the threat to our national security represented by the increased Soviet activity in space? Can the United States in the foreseeable future be able to match the launch capability represented by the new large Soviet booster which can put 220,000 to 485,000 pounds into LEO and 65,000 pounds into GEO?

Answer. [Deleted.]

Question. Table 1 in your written testimony shows a fiscal year 1983 budget compared to a proposed NASA budget of $6.7 billion which tells me that the military space program is significantly larger than the civilian one and growing larger every year. How can the administration justify the lack of single clear space policy which guides our direction into space? I believe on Tuesday, March 16th, you said this figure was $3 billion and Mr. Aldridge used this figure two weeks ago. What does this figure represent?

Answer. The U.S. space program consists of [deleted] strongly interacting and mutually supportive segments: [deleted] Over the years and extensive body of Executive Orders and Presidential Directives have been developed to provide direction and to guide the conduct of these programs.

We in DOD are [deleted].

During the past 20 years, military space systems have made major contributions to force effectiveness. To date, these systems have been employed primarily in a support role. This role is a reflection of (a) the urgency of our needs (better communications, better warning, better surveillance, etc.), (b) the status of technology, (c) budgetary limitations, [deleted].

The apparent lack of a "clear space policy" may be caused by the fact that we have integrated space systems into our force structure to such a degree that they do not appear as separate entities. We believe that this is correct. We do not view space as a "mission", rather as an environment to provide support to our terrestial forces and, in the future as requirements and technology mature, a place wherein unique military capabilities will be developed and employed.

During the past eight months, the DOD and all other Departments and Agencies concerned with space matters have been involved in an exhaustive review of our space programs. The DOD Space Policy Review is in the final stages of coordination and the results should be promulgated as DOD Space Policy within the next few weeks. [Deleted.]

In summary, our space programs are not without focus or direction. We are proceeding on a deliberate program strongly paced by technology, the budget, with due consideration given the sensitivities of both the U.S. and international agencies concerned with the exploitation and use of space.

Question How much money is DOD planning to spend for space platform/space station activities during fiscal year 1983? Is this a cooperative program with NASA? If so, what is the formal mechanism for the NASA/DOD interaction? How much do you estimate NASA is spending on this activity?

Answer. At the present time, DOD does not have any funds identified for space platform/space station activities during fiscal year 1983. At the request of NASA, the Air Force has initiated a study of the potential military uses of a National Space Station. The Air Force has studied the broad requirements which start with the assumption that there will be a space station and asks potential users to identify possible military requirements. The first phase of this study, which consists of an unprioritized list of potential military missions, has been completed and forwarded to NASA Headquarters.

Question. Would you please summarize for us where you see money most wisely spent in the area of space technology to meet the long term defense needs of going into space? Is the DOD planning to pay for these technology developments or does it expect NASA to pay for them?

Answer. With the increasing use of space for [deleted]. We are completing a report for Congress describing the details of the DOD Space Laser Plan to develop the technology base and to resolve the uncertainties in the cost effectiveness of such weapon systems for a variety of potential missions. This work is funded by DOD with no NASA participation.

Funding is also needed to [deleted].

Question. How many DOD flights were on the Shuttle manifest in 1977 when the agreement with NASA was reached on development funding for the Space Transportation System? How many flights are on the manifest today?

Answer. The manifest used as a basis for the 1977 agreement predicted a DOD usage of 112 flights through 1992. The current manifest shows a DOD usage of 124 flights through 1994.

Question. How much is the DOD committed to pay for each Shuttle flight and how was this number established?

Answer. The DOD is committed to pay $12.2 M (fiscal year 1975 $) per Shuttle flight for Materials and Services (largely the cost of a new External Tank and the refurbishment of the Solid Rocket Boosters) and any optional services required for that flight. While the operation and maintenance (O&M) costs of the Vandenberg launch site and the O&M costs for the Consolidated Space Operations Center are not paid on a per flight basis, they are also a "cost of flying the Shuttle" which are normally paid by DOD. The $12.2M was negotiated between NASA and DOD, documented in the 1977 Pricing Policy MOA, and represented the estimated cost of materials and Services (twelve year average) plus a $3M contingency. Optional services vary with each flight and are negotiated individually with NASA on a case-by-case basis. DOD is currently reviewing potential pricing changes with NASA based on NASA projections of increased Materials and Services costs.

Question. What are your views on NASA's plans to consolidate the contracted operations at the Kennedy Space Center?

Answer. We applaud any initiative which will reduce the Shuttle operations costs. We are particularly interested in any initiatives which reduce the manning levels at Kennedy without deleterious effects on operations since those manning factors are used at Vanderberg as well. Reduction at Kennedy will mean proportional reductions at Vanderberg.

Question. Is there a firm requirement for a high energy upper stage that will be capable of putting approximately 10,000 pounds into geosynchronous orbit in 1987? Is this program the MILSTAR program?

Answer. a. While we have not identified specific payloads, we are anticipating a need based upon the forecast weight of some payloads now in the design phase, and expected requirements, especially in the area of survivability. Current conceptual design studies for new spacecraft indicate requirements in the 10,000 pound and higher weights for deployment at geosynchronous orbit.

b. N.A.

Question. If the Air Force were to proceed with the current plans to develop a high energy upper stage to meet a 1987 IOC, what do you foresee the role of NASA would be in such a development? Do you foresee the need for an orbital transfer vehicle as soon as 1990? Do you feel that it is NASA's or the Air Force's place to develop such a vehicle? Are you aware of new engine developments for high energy upper stages?

Answer. (a) NASA will contribute approximately one third of the cost of the program based upon its requirements. The program management structure will depend upon the concept selected. Obviously, if a Centaur based vehicle is selected, the existing NASA Centaur management structure will be heavily involved.

(b) If high energy upper stage is developed to meet a 1987 IOC, we do not see a currently defined need for the OTV.

(c) Typically, developments are the primary responsibility of the agency with the operational imperative. To the extent that the OTV development likely will be undertaken to satisfy aggregate national requirements, both the Air Force and NASA can be expected to participate as soon as 1990 to meet DOD requirements.

(d) Yes; we are aware of NASA efforts to extend Pratt and Whitney cryogenic engine capabilities. In addition, Rocketdyne is investigating IR&D money in a higher energy upper stage engine development program.

Question. NASA is spending money during fiscal year 1982 and 1983 for development of new concepts for heavy lift launch vehicles such as the SRB-X. Would you describe for us what uses the DOD might have for this capability? Are you planning to contribute to the NASA budget for development of these systems? How much money are you spending on these concept studies?

Answer. The DOD has [deleted].

Question. The primary justification given by NASA to date for the SMM Repair mission is that it will help sell such a capability to the Department of Defense. Do you in fact have a direct need for such a capability? Do you in fact have a satellite which could be used for a repair mission in place of the current one porposed as a demonstration? Is FLTSATCOM No. 5 such a candidate?

Answer. (a) The Air Force [deleted]. Demonstration of module replacement of the SMM satellite should provide useful procedural information and, perhaps, engineering recommendations to support future planning and design. Recovery and analysis of an SMM module will provide useful data on the refurbishment potential of components similar to those used by the Air Force.

(b) No. FLSATCOM No. 5 is in an orbit inaccessible for repair operations.

Question. In your opinion, what organization should ultimately be responsible for the operation of the Space Shuttle? If either a private commercial group or a government-owned contractor-operated organization were to operate the Shuttle what problems would you foresee for DOD use of the system?

Answer. At this time, with a relatively new Shuttle system, and without detailed examination of other management approaches, it is premature to select a far-term or ultimate Shuttle operation organization. In the near-term, we believe that DOD and NASA should proceed with the current management arrangement outlined in their Memorandum of Understanding, dated 27 March 1980, and should continue to refine these operations and management responsibilities as the Shuttle system matures. If either a private commercial group or a government-owned contractor-operated organization were to operate the Shuttle, we foresee potential problems in the following areas: insuring that the highest priority is placed on planning and execution of national security missions; retaining control over all activities relating to security for DOD missions; insuring that the STS system retains and meets future national security launch and on-orbit performance requirements and insuring that DOD retains the authority and ability to exercise its national security responsibilities during STS operations.

EARTH REMOTE SENSING SATELLITE

Question. What is the position of the DOD regarding the development of an operational private sector earth remote sensing satellite? What technological, organizational and other types of constraints, if any, should be placed on such a system?

Answer. DOD is not a major user of such data; the Corps of Engineers and Defense Mapping Agency together budget some $350,000 for available data in research applications. Other DOD use is incidental. National security is not an issue in DOD, however safeguards are needed to control data flow in national emergency situations and to protect against technology transfer.

Pressures for classified technology transfer to support a viable private sector operation are of concern. The ability to deny data of military utility and to impact upon the data distribution mechanism are areas of concern. Specific policies and enforcement mechanisms must be established.

Question. Has there been any application of the guidance and control capabilities as demonstrated by the extended planetary exploration missions to the needs of the Department of Defense?

Answer. Yes. The DOD has been directly involved with the Jet Propulsion Laboratory (JPL) in a number of joint programs that exploit JPL's guidance and control capabilities developed for extended planetary missions for use in DOD space systems. These joint programs are making significant contributions to the development of autonomous capabilities for DOD space systems.

Question. Has the DOD any plans to use the NASA developed Nuclear Electric Propulsion technology in the foreseeable future?

Answer. Many conceptual studies of future DOD space systems have indicated a need for this type of propulsion system. It would be especially appropriate for large structure sensor systems which are most economically assembled in low earth orbit, then boosted into geosynchronous orbit with steady, low thrust means such as nuclear electric thrusters.

USER CHARGES FOR THE USE OF THE NAVSTAR GPS SYSTEM

Question. In last year's testimony we discussed the possibility of user charges for the use of the NAVSTAR GPS system. Has there been any decision on whether to implement such charges?

Answer. No, we have not yet reached a final decision on overall user charges for GPS. We have an extensive study underway on the subject of GPS user charges. An outcome of the study has been the decision to charge our NATO allies an annual fee for use of the highest precision service available from GPS. A final decision on the more generally available standard positioning service has not yet been reached. A preliminary report on our progress to date was submitted to the Congress on March 1, 1982.

Question. Have you any plans to test a submarine laser communications satellite in the foreseeable future?

Answer. The Submarine Laser Communications (SLC) Program is developing the technology for a first end-to-end SLC satellite experiment with residual operational capability. A decision as to whether this first experiment is to use the laser satellite approach or the relay mirror satellite approach will be made in late fiscal year 1984. A decision to commit to development of the hardware for this space segment will also be made in fiscal year 1984 and will depend on technology status and funding priorities for major programs within DARPA.

Question. It has been widely circulated in the aerospace press that a number of informed people believe that this nation is spending only about 10 percent of space laser research funding in this program's most productive areas. Can you tell us whether this is true, and, if so, just where should we be spending our money?

Answer. I believe the DOD research in space lasers represents a well balanced investment between nearer term technologies and those longer term approaches that offer the potential for higher performance. The are many factors which must be considered in making such investment decisions including the laser wavelength, the fuel effficiency, and the relative maturity of the laser device and supporting technologies. The range at which a laser weapon can be effective increases as the wavelength decreases, leading to a desire to develop lasers operating at short wavelengths. To realize this potential one must also improve supporting technologies of optics and pointing precision as the wavelength decreases. Fuel efficiency is also important since it determines the weight of the expendables that must be used to produce the laser energy and thus, for space-based weapons, the number of shots that can be carried on a weapon platform.

[Deleted.]

Thus the program shows a proper balance between approaches which offer potential in the nearer term and those longer term technologies which may provide a means to scale to higher performance for the most stressing mission requirements.

Question. (1) What is the status of the Talon Gold Program? (2) What is the status of the HALO Program to date? (3) What is the status of the LODE Program?

Answer. The Talon Gold Program is proceeding on schedule towards a first flight in late fiscal year 1987. The brassboard test activities during fiscal year 1981 were highly successful, demonstrating performance levels commensurate with the Talon Gold objectives. The source selection for the flight hardware development (Phase II) was held in October of 1981 and a contract was signed with Lockheed Missiles and Space Corporation in January of 1982. Negotiations with NASA on the use of NASA-ESA Spacelab equipment to support the Talon Gold experiment is proceeding well with a final agreement expected during the third quarter of fiscal year 1982.

The DARPA HALO program consists of various tasks to develop infrared sensor components and establish the manufacturing base necessary to support their application in system development program decisions in the late 1980's. Status can be briefly summaried by task areas:

a. Mosaic infrared focal plan detector arrays [deleted] fully integrated with multiplexer and a simple signal processing functioins have been demonstrated.

b. Large, ultra-lightweight optical mirrors have been built and are being tested [deleted].

c. [Deleted.]

d. High efficiency, long lived cryogenic refrigerators are essential to infrared sensor operation in space; one such unit has been developed and is being life tested with design and construction of a more efficient machine just getting underway.

The HALO program has been successfully meeting its development milestones. Several of the specific components already developed are being considered for inclusion in the USAF Advanced Warning Sensor Program as part of the DARPA/USAF Joint Technology Program.

The concept definition phase of LODE is completed, proposals for the follow-up detailed design phase have been received from both Hughes Aircraft Company and the Lockheed Missile and Space Company, and the DARPA/Air Force source selection process is nearly complete. [Deleted]. Source selection and initiation of final design with one contractor is planned for approximately March 1983.

Question. Is DOD conducting any research on Multi-Linear array technology?

Answer. DARPA is developing two dimensional infrared detector arrays [deleted].

Question. Would you please elaborate on the reorganization of your office?

Answer. I have proposed several organizational changes within my Office with the aim of exercising my major responsibilities more effectively. The proposed establishment of two Assistant Secretaries of Defense (ASD) reporting directly to me—one for Development and Support, and one for Research and Technology—will create a three-man USDEW top management team, led by me, to set the standards and pace, and to move toward the objectives set by the Secretary of Defense in the critical areas of modernization, readiness, acquisition management, and the technology base.

The proposed Assistant Secretary of Defense for Development and Support would be responsible to me for the management of our modernization plans and programs, including mission area assessments, and for emphasizing readiness early in the R&D process including relaibility, maintainablility, sustainability and logistical support goals. He would assist me in developing guidance on investment objectives to the Secretaries of the Military Departments, and in providing all of the participants in the acquisition process with analyses of the investment balance and of the effectiveness of proosed investment programs in meeting broad mission needs. This proposed ASD for Development and Support would also serve as the Principal Deputy Under Secretary of Defense for Research and Engineering.

The proposed ASD for Research and Technology would assist me in managing our technology base—planning a comprehensive science and technology program, directing basic research, interfacing with the nation's technical and scientific community, and improving the transition of technology into our deployed systems. A key responsibility would be to assist the Services in developing advanced technology system options, and to use technology innovatively to increase total military force capability. He would also serve as the Director, Defense Advanced Research Projects Agency.

As you are well aware, centralized management of space activities within the DOD has been discussed for some time and our organization for space has been evolving fairly rapidly over the past four years. Within my office, I have asked Dr. Cooper, Director of DARPA, to act as the principal focus for review of space research and dvelopment across all mission areas. This action will sharpen our forces for space activities and bring increased management attention to his important area. We are continuing to evaluate organizational alternatives to effectively manage our space activities.

DOD CONTINUATION OF NASA PROGRAMS

Question. The following Systems Technology programs are being terminated in fiscal year 1982 and have been deleted from the NASA aeronautics fiscal year 1983 budget:

1. Composite Primary Aircraft Structure
2. Energy Efficient Transport
3. Energy Efficient Engine
4. Advanced Turboprop Systems
5. Laminar Flow Control
6. Aeronautical Systems Studies
7. Integrated Aerospace Vehicle Design
8. Aeroelasticity of Turbine Engines
9. Helicopter Transmission Technology
10. Tilt Rotor Systems Technology
11. Terminal Configured Vehicle
12. Powered Lift Technology

Which of these programs or parts thereof is DOD funding now or will pick up in fiscal year 1983? Please provide some program detail.

Answer. The Department of Defense will be providing a logical continuation of those programs terminated by NASA in the context of applying the already developed technology base to our specific military system needs. A more specific enumeration for each of the terminated programs is as follows:

Composite Primary Aircraft Structure.—[Deleted.] This DOD program will have direct application to the commercial transport industry. A multitude of by-products will also surface through on-going DOD efforts from the all composite helicopter fuselage, and a critical wing box center section for fighter type aircraft. We are also pursuing the development of metal-matrix composites with structural performance similar to non-metallic composites but having the capability of being worked with existing tools and machinery. Planned DOD funding in composite materials for aircraft is approximately $68 million in fiscal year 1983.

Energy Efficient Transport and Laminar Flow Control.—Both of these technology thrusts have principal applications to a new transport aircraft design. As such, the impact of the NASA program could not be felt until the next transport (C-5 replacement) acquisition. Within the technology base, we have on-going programs in all three Services in active control technology and propulsion/airframe integration for producing more efficient airframe designs. Planned DOD funding in the area of active control technology is approximately $22 million in fiscal year 1983. To the extent that these technologies are applicable, they will be incorporated in our next generation transport or Navy patrol craft. We did make a KC-135 available to NASA for testing of winglets which demonstrated a 6 percent reduction in cruise drag and we will continue to work in this area.

Energy Efficient Engine.—The component technology which has been, or will be, demonstrated in this program is of course available to the major NASA contractors, General Electric and Pratt and Whitney. To the extent that this technology is applicable to our advanced technology engine needs, it will be incorporated into the major DOD technology demonstration program, Advanced Turbine Engine Gas Generator (ATEGG), Advanced Propulsion Subsystem Integration (APSI), and Joint Technology Demonstrator Engine (JTDE), in which both General Electric and Pratt and Whitney participate. Planned DOD funding for these programs is $58 million in fiscal year 1983. Our understanding is that NASA plans to use the engine hardware in-house at Lewis as advanced technology testbeds, and so the program will also continue in this manner.

Advanced Turboprop Systems.—It is our understanding that NASA plans to continue the basic technology effort associated with the unique element of this program—the prop-fan, and we view this effort as very important. Although the acquisition of the additional C-5 transport aircraft precludes an opportunity for near-term military applications of this technology, it should be of great benefit in the development of a C-5 replacement planned for sometime around the year 2000. Accordingly, we shall continue to follow NASA's work in this area very closely, and we are actively considering appropriate complementary efforts to our advanced propulsion technology programs within the next few years.

Aeronautical Systems Studies and Integrated Program for Aerospace Vehicle Design.—These programs deal with the development of a computer software system for total management of aerospace vehicle design; and mission, systems, and conceptual analyses for advanced civil and military aeronautical systems. While the NASA military studies were coordinated with the proper DOD elements, they were of generic types of aircraft, rather than focused on a specific operational requirement. The Military Services conduct similar studies aimed at somewhat more specific requirements and tend to be more near term. If NASA activities are eliminated in this area, DOD must broaden the range of our studies to insure that development of far term technology requirements are not overlooked. Planned DOD funding in this area is approximately $5 million in fiscal year 1983.

Aeroelasticity of Turbine Engines and Helicopter Transmission Technology.—These are rather modest programs (a total of $2.4 million in fiscal year 1981, on initial request of $1.5 million in fiscal year 1981, and a current estimate of $0.8 million in fiscal year 1982) which are joint programs with DOD. Our efforts in these areas will continue, and we will endeavor to augment these efforts in order that progress will not be unacceptably slowed. Planned DOD funding in those areas is approximately one million dollars in fiscal year 1983.

Tilt Rotor Systems Technology.—The XV-15 program has been jointly funded by NASA and DOD. Both NASA and the Services are continuing to fly the aircraft in operationally oriented tests. The Navy will be taking the XV-15 to sea this summer for limited trials on board a LPH or LHA class ship. The tilt rotor is a prime candidate for the new Joint-Service Vertical Lift (JVX) aircraft development program. Planned DOD funding of the JVX program is $50 million in fiscal year 1983.

Terminal Configured Vehicle.—This NASA program is oriented towards developing improved crew station arrangements, crew procedures and traffic control procedures for highly congested commercial/terminal areas. We have similar technology base programs that focus on crew station design and crew performance for the accomplishment of the primary military mission. However we are not addressing the traffic control aspects because most of our operations are in other than highly congested terminal areas.

Powered Lift Technology.—The technology has broad military application as evidence that the NASA QSRA experimental aircraft was successfully operated from the flight deck of the U.S.S. *Kitty Hawk* last fall. The Air Force has initiated a new technology program starting in fiscal year 1983 to modify and flight demonstrate STOL performance on an existing inventory fighter. Some of the technologies to be included in this program are high lift wing, thrust vectoring and reversing, rough field landing gear and integrated engine/flight controls. This effort utilizes the technology validated by the NASA QSRA program. Planned DOD funding for the STOL demonstrator is $1.3 million in fiscal year 1983.

[Whereupon, at 12:05 p.m., the subcommittee was adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1983

TUESDAY, MARCH 30, 1982

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, D.C.

The subcommittee met at 9:30 a.m., in room 235, Russell Senate Office Building, Hon. Slade Gorton presiding.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. I call this meeting to order.

The 1958 Space Act established a firm basis for NASA's research in the sciences using the unique environment and vantage point of space. The research programs which have subsequently developed observed the surface of the Earth and the oceans, probed the atmosphere and the environment in the immediate vicinity of the Earth, studied the Sun in its quiescent as well as eruptive phases, and related these findings to the knowledge of the Earth's environment.

NASA's programs continue to study man's ability to work in space, explore the Moon and the planets to discover the history of the solar system, and map the sky and all regions of the electromagnetic spectrum in an attempt to probe the past and the future of our universe.

Basic research as performed and supported by NASA has unequivocally demonstrated that it contributes much more to our Nation than just the creation of new knowledge and the development of a basic understanding of the world in which we live. Leadership in fundamental research is the foundation upon which our country's preeminence in technology is based, and it is this latter strength upon which both our national security and our economic success ultimately rests.

In the final analysis, the high quality of life enjoyed by the citizens of the United States is derivable from our continuing emphasis on the exploration of both the near and the far universe in which we live. History has shown that during times of fiscal restraint, moneys allocated for research are often used as a buffer to cushion major hardware development programs from the actions of the budget cutters.

The argument used is typically that reducing basic research causes less pain than cutting hardware programs where drastic impacts are visibly apparent. The foolishness and shortsightedness of this argument is obvious when one traces the histories of some of the discoveries which have had the greatest impacts on our quality of life.

The transistor and the laser were both esoteric ideas in scientists minds long before anyone considered the possibility of powerful computers in the home or microsurgery on the human eye. It is literally impossible to predict which research ideas will bear fruit 10 to 20 years from now.

Only a broad spectrum of research avenues will provide us with the choices necessary for sustained scientific and economic growth. I believe that it is time to take a careful look at the future of space science in this country. It is time to reestablish our major goals based upon our achievements of the past two decades and to develop a plan for supporting these new goals and for successfully accomplishing them.

This process will require a recommitment on the part of all parties to the pursuit of a dynamic space science program by this country as a part of a national space policy. It will mean a commitment on the part of the scientific community to support the overall goals of the space program and to work within it to accomplish these ends. It will mean a sustained commitment on the part of the administration to a budget for space science and applications research.

We must reaffirm this country's commitment to leadership in all of the sciences because nothing less than our country's future, specifically the kind of world in which we wish to live, is at stake.

With that, I announce that the chairman of this subcommittee is, unfortunately, absent and we will be operating in relays. I will be able to be here until approximately 10 o'clock for the first witness or so, and then another will succeed me shortly after that time.

We will start with an introduction by the committee's chairman, Senator Packwood.

The CHAIRMAN. Mr. Chairman, it is a privilege this morning to introduce one of the witnesses who will testify later. How he came to be testifying today was somewhat oblique. He has exchanged correspondence with me in the past, but some time ago he started exchanging correspondence with Dennis Barnes, our chief of staff on this committee, and some others on the staff, and they were very impressed with him.

Consequently, they asked him to come down, and he came down at his own expense last January to visit the staff. They were stunned to learn that he was only 19 years old and a sophomore at Massachusetts Institute of Technology. He has been interested in both science and politics since his freshman year in high school when he began taking math and science courses and joined the debate team, and during his senior year in high school he placed fourth in the Nation in the National Forensic League Student Congress while taking science courses at the local community college.

He is currently an undergraduate research assistant at MIT and is a physics and mathematics major. When he was here last January he visited the staff of this subcommittee to lobby for the science budgets for both the National Science Foundation and NASA. He also visited and was well received at the NASA headquarters, the Office of Science and Technology Policy of the National Research Council, and the staffs of certain Senators.

He again paid his own way down here today and will be testifying following this panel, and it was only recently that the staff put two and two together and realized that he is from a suburb of Portland, Oreg., and that he and I had carried on a correspondence for an extended period of time. I think it is to his credit that he did not bother to push himself on the staff and say "I know Senator Packwood," or "I'm from Oregon and I'm sure he would want me to testify."

He has made it here on his merits, and at 19 years old as one of the extraordinary leaders in the science education community.

I will be off, Mr. Chairman, to another committee.

Senator GORTON. Thank you very much, Mr. Chairman.

We will start with Dr. Edelson, Associate Administrator for Space Science and Applications, and if you will introduce those who are at the witness table with you.

STATEMENT OF DR. BURTON I. EDELSON, ASSOCIATE ADMINISTRATOR FOR THE OFFICE OF SPACE SCIENCE AND APPLICATIONS [OSSA], NASA, ACCOMPANIED BY ANDREW STOFAN, DIRECTOR-DESIGNATE TO THE LEWIS RESEARCH CENTER IN CLEVELAND; SAM KELLER, DEPUTY ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS; AND PAUL ANDERSON, DIRECTOR, ADMINISTRATION AND RESOURCES MANAGEMENT FOR OSSA

Dr. EDELSON. Thank you, Senator. I am very pleased to be here this morning. With me today is Andrew Stofan, who was the Acting Associate Administrator before my appointment and who is now the Director-Designate at the Lewis Research Center in Cleveland. Also with me is Sam Keller, the Deputy Associate Administrator for Space Science and Applications; and Paul Anderson, the Director of Administration and Resources Management for OSSA.

Senator, I have a written statement which I would like to submit for the record.

Senator GORTON. It will be included in the record in full.

Dr. EDELSON. Thank you. The program which we are presenting is a very exciting one. I appreciate the very strong support for Space Science and Applications that the subcommittee has provided in the past, and look forward to working with you in the future in the pursuit of this very exciting program. We have had a number of recent successful experiments flown on the Shuttle orbital test flights, and we are looking forward to carrying out many more scientific investigations over the next few years.

Before I discuss the budget with you, I want to share one example of Shuttle-based research which has borne fruit very recently, and I think we will be hearing a great deal about it in the future. I wish to direct you to the screen behind us.

The second Shuttle orbital test flight [fig. 6] on November 12 to 14, 1981, contained an experiment known as Shuttle Imaging Radar [SIR-A], and a synthetic aperture radar which was developed by the Jet Propulsion Laboratory. During that 2-day flight we acquired data over 10 million square kilometers. It is interesting to compare the results of SIR-A with Landsat multispectral optical and infrared imagery. You can see from this photograph [fig. 36] that of Santa Ynez in California it is mutually supporting.

It is interesting to note that how you get different information from the two types of imagery and that the amount of information from both images together is much greater than the information derived separately. The reflectivity of a surface depends upon its scattering properties and the lighting geometry. The scattering, in turn, depends upon surface roughness and electrical and chemical properties of rocks, dirt, vegetation, and so on. Optical and infrared scattering are dominated by electronic and vibrational effects at the molecular level. Brightness is dominated by reflection and absorption of the surface, With radar imagery you have control over the optical illumination; and, it is, of course, available in all weather through clouds, fog, and day and night.

The radar imagery, however, is sensitive to surface slope and roughness at scales that approximate geological units. There is an overlay that we can display that will bring out the superiority of the radar for mapping heavily vegetated regions when compared with the optical and infrared superiority for what is called lithologic or map contour and surfacing mapping.

The combination is synergistic. We are very excited about this first experiment, and I am persuaded that we will use the combination in the future.

What I would like to emphasize in this example is that we have been able to use these first orbital test flights of the Space Shuttle very successfully for conducting science and applications experiments; and we are gaining information that will make our future developments more meaningful

Now, with that slight bit of program introduction, I will go directly to the budget request. We only have time for an overview, so I will show the pie chart first [fig. 35], which shows that we have a fiscal year 1983 request of approximately $1 billion. The applications budget is $316.3 million; physics and astronomy, $471.7 million; planetary exploration, $154.6 million; and life sciences, $55.7 million. This request allows for continuation of ongoing development activities on our major high priority projects, such as: the Landsat-D, which is to be launched this summer; the Space Telescope, which is to be launched in 1985; Galileo, our major planetary mission, which is scheduled to be launched on a Shuttle/IUS in 1985; the support of the ESA ISPM mission, which is scheduled as a 1986 launch; and the Gamma Ray Observatory, which will be launched in late 1988.

There are a great number of smaller projects, such as the Explorers, which are being continued: the Infrared Astronomy Satellite which will be launched later this year, and the Active Magnetospheric Particle Tracer Explorers which will be launched in 1984. I won't go through the long list of them, but there are also several other projects and experiments ongoing which are included in the budget.

The buildup of the Shuttle Spacelab payloads will be increasing as the Shuttle becomes operational. Buildup in life sciences also reflects Shuttle needs, in particular, the need for increased understanding of medical problems associated with manned space flight.

We will be receiving information from the flight that is up at the present time.

We have had a number of concerns about programs that we are not able to support, but we are hard at work on the technology to support future missions. For example, we are studying a simpler, less expensive Venus mapping mission which we hope to pursue in future years to obtain a great deal of the information that we had hoped to get with the Venus Orbiting Imaging Radar [VOIR] mission. We are also reorienting the communications work to emphasize advanced technology development rather than service demonstration of the 30/20 GHz program.

In summary, Senator, I would like to show you the detailed budget, which you will see on figures 9 and 10. You can see the columns of figures that total $998.3 million, by the line items which are included in the budget. I think rather than to go through those in any detail, I will leave them in the written record and be available for your questions.

Senator GORTON. Thank you very much, Dr. Edelson.

I will have just a very few questions but we have a number of others which we will submit to you in writing. The time constraints today just simply do not allow us the luxury of a great deal of detail in this respect.

I would like to ask you for NASA's current justification for performing the solar maximum mission repair retrieval, how urgent it is, at what time, if it is deferred, will it simply become impossible to accomplish?

Dr. EDELSON. As you know, Senator, the Solar Maximum Mission [SMM] repair has been justified by us for valid scientific reasons. Mr. Stofan can provide more information to support that.

Mr. STOFAN. The science community and the National Academy of Sciences support the SMM retrieval and repair from a purely scientific point of view. We have discovered a variability in the solar constant that may have a direct effect on the climate here on Earth, and we are looking for a direct correlation. The SMM is the only spacecraft that can make these measurements; so, it is extremely important to keep it operational.

Also, the solar maximum cycle is stretched out over a longer period of time. This is different from the cycles we have observed in the past. The maximum will continue for a while; so, the repair of the spacecraft and instruments will allow us to observe the Sun through its maximum and to watch the variability of the solar constant. Therefore, we feel it is very important scientifically.

Senator GORTON. How long do you have? What kind of time limit do you have before it is impossible to accomplish the repair?

Mr. STOFAN. The time limit is dependent upon the solar activity. As the Sun's energy output varies, it varies the atmospheric density which in turn varies the drag on the spacecraft. It is predicted in a band, depending on whether the Sun's activity is going to go down or go up. We want the spacecraft in the part of the atmosphere where it is guaranteed not to tumble away from the astronauts' reach. The span on that is about a year or two, from 1984 to 1985.

Senator GORTON. In other words, you do have to get at it immediately.

Mr. STOFAN. Yes. We cannot wait several years and then do it.

Senator GORTON. Dr. Edelson, has the technology transfer program at this point served its function so that it could be terminated without considerable loss?

Dr. EDELSON. Let me turn that question over to Mr. Keller.

Mr. KELLER. Mr. Chairman, the technology transfer program is one of the activities we have had ongoing for a number of years. The program has been directed to assisting the user in utilizing the information, for example the data that we derive from the Landsat program. I do not believe you would ever describe that activity as being completed. It can go on as long as you want. We have phased the activity down in an attempt to let the private sector provide support where appropriate. At the same time, some of the activities that were previously identified with the technology transfer program are being included in the core Landsat activity. For example, we have three regional centers, one at Goddard, one at Ames, and one at NSTL, which we will continue at least throughout the next year with available funds. So while we are scaling the technology transfer efforts back, there are certain portions of the activity that logically fit into the prime Landsat program which we will continue to support.

Senator GORTON. Thank you.

One last question, Dr. Edelson. What would you describe as the most significant development problems to this point in connection with the Space Telescope program? Have the major technical goals changed since the beginning of the program?

Dr. EDELSON. No, the major technical goals have not changed since the start of the program, Senator. Regarding our problems to date, I would say we have no major problem at this date, but we have a number of minor problems. The major subsystem of the Space Telescope is the mirror. Finishing that has been a very long and tedious process. It was completed successfully, with much better tolerance than was prescribed, although there were a number of difficulties. The Perkin-Elmer Co. has been doing a superb job, but they have been late in doing it. We have some contractual difficulties and a number of difficult contractual interfaces. In summary as of this date, everything seems to be coming along quite well and we think the Space Telescope will be the cornerstone of our space astronomy program.

Senator GORTON. Thank you, and thanks to the other members of the panel. As I said, we have a substantial number of additional questions which we will submit to you and hope to get your responses in writing, which responses will be included in the record.

Dr. EDELSON. Thank you, sir.

[The statement follows:]

STATEMENT

of

DR. BURTON I. EDELSON
ASSOCIATE ADMINISTRATOR FOR
SPACE SCIENCE AND APPLICATIONS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

INTRODUCTION

Mr. Chairman and Members of the Subcommittee:

I am pleased to be here today to review the Space Science and Applications program and to discuss our proposed budget for FY 1983. This is my first appearance before this Committee. I know how strongly you have supported the Science and Applications programs in the past. From my perspective outside of NASA, I have long believed that the accomplishments of these programs have been a source of pride to the nation. I look forward to working with you to continue the tradition of achievement which has produced so much new knowledge and new technology and which has added immeasurably to the prestige we enjoy among other nations.

For the last decade, the agency has brought forward separately a Space Science program and Applications program. Today, the programs are once again combined, and I believe that a few explanatory remarks concerning the philosophy and intent of the new organization are in order. The consolidation on December 3, 1981, of the Office of Space Science and the Office of Space and Terrestrial Applications into the Office of Space Science and Applications was part of a general reorganization of NASA Headquarters intended to assure more efficient delegation of authority to line managers and to simplify and clarify reporting lines for the field centers. (Fig. 1) In this arrangement, the Office of Space Science and Applications will have responsibility for the management of the Jet Propulsion Laboratory and the Goddard Space Flight Center, the two centers where most of the science and applications programs are located. We will, of course, continue to have important elements of our program at other centers and will be working very closely with the Associate Administrators for Aeronautics and Space Technology and for Space Transportation Systems to ensure that those elements are properly staffed, managed and directed.

In carrying out the reorganization, great care has been taken to preserve the strengths of NASA's science and applications programs. (Fig. 2) With this combination, I believe that we now can enhance our ability to understand the Earth as a planet and to study the complex coupling between the solar wind, the Earth's magnetosphere and the Earth's atmosphere in a comprehensive manner. One of the most important things we have learned in the 24 years of the space age is that comparative studies of the Earth and other planets lead to a deeper understanding of the general question of the evolution of planetary atmospheres and surfaces and of the influence of our space environment on the Earth itself. We now know that we cannot consider the Earth as an isolated body in space gently warmed by the Sun's radiation. Rather, both the Earth and the Sun are part of a coupled system in which steady streams and intense bursts of atomic particles blow outward from the Sun, colliding with the atmospheres of the Earth and the other planets. At the Earth these particle streams provide the energy for the aurorae, magnetic storms, and the radiation belts. Lines of magnetic force, atomic particles and electric currents surround the Earth and interact with the atmosphere. We are only now beginning to understand how this coupling affects the Earth, its weather, its climate and our own communications.

Our total Space Science and Applications program is directed towards understanding the world we live in and the environment in which that world exists. Some of our program deals with the larger cosmic environment and the development of a very long-term perspective. Some of it deals with more immediate concerns such as atmospheric ozone, weather, climate, earthquakes, ocean currents, sea ice motion and natural resources, or with ensuring the health and effectiveness of our astronauts. The two aspects of the program are different sides of the same coin. They are equally important.

HIGHLIGHTS OF THE PAST YEAR

The strengths of the space science and applications programs are best illustrated by our accomplishments. I would like to review a few of the highlights of the past year.

Voyager 2

The Voyager 2 encounter with Saturn showed the great value of the two-encounter mission. (Fig. 3) Based on an analysis of the wealth of data returned by Voyager 1, scientists were able to reprogram Voyager 2 in order to study key areas of the Saturnian environment in great detail. Major objectives of the encounter included a comparative study of the atmospheres and magnetospheres of the two giant planets, Jupiter and Saturn, more detailed examination of the complex ring structure and a first close-up reconnaissance of several of the satellites of Saturn. The encounter, with closest approach to Saturn by Voyager 2 occurring on August 26, 1981, was a resounding success. Even the difficulties with the camera scan platform which occurred shortly after Voyager 2 passed through the ring-plane on its outbound journey did little to mar the success of the encounter.

Small-scale structure in the atmosphere of Saturn was identified including white ovals and alternating eastward and westward high-speed jet streams similar to those on Jupiter. Ultraviolet absorbent materials at the highest latitudes were discovered. Similar phenomena were observed at Jupiter and are thought to be due to complex hydrocarbons formed by auroral activity.

Basic new information on the structure of the rings was obtained. Few gaps were found to exist and those gaps which were identified were very sharply delineated. The imaging experiment showed eccentric ringlets in nearly every gap. Although gaps and eccentric ringlets suggest the presence of imbedded moonlets, a systematic search of the gap in the inner Cassini division revealed neither moonlets nor suggested any alternative explanation for the observed phenomena.

All 17 previously known satellites were observed, several from much closer range than that achieved by Voyager 1. There appears to be a tendency for the brighter satellites to be the most evolved. The darker ones are more primitive and of irregular shape, perhaps indicating the original rock and ice composition. Brighter, smoother surfaces may be the result of internal heating which has melted the icy crust. Recently, four and possibly as many as six, new small satellites of Saturn were discovered in the post-encounter examination of the Voyager 2 data. These are all small bodies, ranging in diameter from 10 to 20 kilometers.

Both Voyager spacecraft continue to speed toward the outer reaches of the solar system. It is estimated that Voyager 1 will cross the boundary of the heliosphere -- the bubble blown in the interstellar medium by the solar wind -- in 1990. It will be the first object launched from Earth to do so. Voyager 2 will encounter the planet Uranus in January 1986 and, if the spacecraft remains healthy, it will continue on to an encounter with Neptune in 1989. Both spacecraft will make continuous measurements to characterize the solar wind and await the onset of the flux of low-energy, cosmic ray particles from sources outside the solar system.

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Dynamics Explorers

The two spacecraft of the Dynamics Explorers (DE) mission were launched on August 3, 1981. The mission is studying the interactions between the hot magnetosphere at high altitudes and the cool ionosphere at low altitudes, particularly the exchange of energy between the two regions, the acceleration of particles, and the processes that lead to aurorae. (Fig. 4) DE-1 is obtaining high resolution images which, for the first time, enable us to view the entire auroral zone and study the dynamic motions of the aurorae while particle streams, electric currents and plasma waves are simultaneously measured in situ by both DE spacecraft.

Solar Mesosphere Explorer

The Solar Mesosphere Explorer (SME), launched on October 9, 1981, is making measurements needed to understand the complex chemical processes taking place in the mesosphere, the Earth's middle atmosphere. (Fig. 5) Included in the data are measurements of the temperature and the concentrations of ozone, atomic oxygen, and nitrogen dioxide. The scientists working with these data have observed up to 30% variations in the ultraviolet reaching the Earth to drive mesospheric ozone reactions.

OSTA-1

OSTA-1, the Shuttle's first scientific payload, was launched on the second Shuttle flight on November 12, 1981. (Fig. 6) Although the mission was shortened, the OSTA-1 payload was an outstanding success demonstrating the Shuttle's capability to support scientific investigations. Over 10 million square kilometers of radar imaging data and 80 thousand linear kilometers of rock spectral reflectance data were obtained. (Fig. 7) The first global measurements of the distribution of carbon monoxide in the atmosphere and the first motion pictures of thunderstorms from space were obtained. Important data were also obtained on the distribution of marine algae in the ocean.

Visible Infrared Spin Scan Atmospheric Sounder

Flight of a Visible Infrared Spin Scan Atmospheric Sounder (VAS) on both GOES-4 and -5 has shown that temperature sounding is feasible to an accuracy of 1.5-2.0 °C from geostationary satellites. (Fig. 8). Land and water temperatures can be mapped to about 1 °C, once corrections have been made for atmospheric water vapor and clouds. Wind velocities can be calculated from short-term cloud or water vapor image displacements to within 2-3 meters/sec. Cloud height, type and cover estimation can be improved with the refined radiative transfer physics that is now possible using the increased number of infrared bands available on VAS. These data are helping NASA researchers to understand the development of severe storms. NOAA is pursuing the use of these new data products to enhance operational weather and marine forecasts.

BUDGET SUMMARY

The total budget request for FY 1983 for the Office of Space Science and Applications in Research and Development funds is $998.3 million. For your convenience, I will present the budget summary in the form familiar from past years. (Figs. 9 and 10) However, as I discuss the individual elements of the program in more detail, I will use an approach that more closely fits the new organization. Our Research and Program Management and Construction of Facilities requirements will be discussed in separate hearings.

The budget I am going to present recognizes support of the Presidents' economic recovery program. It is important to realize, however, that the FY 1983 Budget request allows for continuation of ongoing development activities on our high-priority projects. It supports the continuation of the Landsat-D development leading to a launch in 1982; continues the space telescope development leading to a launch in the first half of 1985; continues the Galileo development leading to a single Shuttle/Inertial Upper Stage launch in 1985; continues development of instruments and support for the single spacecraft International Solar Polar Mission to be launched in 1986 on a single Shuttle/Inertial Upper Stage; and starts the hardware development of the Gamma Ray Observatory leading towards a planned launch in 1988. The Spacelab payload development, Explorer development, as well as our research and other support efforts are also continued at a level which permits continued forward progress.

In Resource Observations, requested funding will continue to support a third quarter 1982 launch of Landsat-D. Extended mission operations funds will provide for continued Landsat 3 operations and monitoring of Landsat-2. Planned Shuttle/Spacelab Payloads funding will support future flights of the Large Format Camera. The Geodynamics Program will continue its efforts to improve our understanding of the dynamic processes that occur within and at the surface of the Earth. The AgRISTARS program will continue to develop methods for assessing worldwide agricultural resources by identifying and separating the remote sensing signatures of various forms of vegetation. The Applied Research and Data Analysis effort will continue to develop new remote sensing capabilities, with particular emphasis on advanced solid state sensor development.

In Environmental Observations, requested funding for the Upper Atmospheric Research program will enable us to continue to carry out our Congressional mandate to improve our understanding of the upper atmosphere. Requested funding for Shuttle Spacelab Payloads development will support analysis of data from environmental instrumentation on OSTA-2 and will support completion of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) instrument for future flights. We plan to phase out the Operational Satellite Improvement Program. The budget request assumes NOAA will pick-up the responsibility for future operational satellite system improvements. NASA expects to complete ongoing development of instruments such as the Solar Backscatter Ultraviolet Radiometer (SBUV) and spacecraft systems which directly support NASA's research goals. Funding requested for the Earth Radiation Budget Experiment (ERBE) spacecraft will support a 1984 launch. The ERBE instrument development activities will also continue to prepare for launch on NOAA spacecraft beginning in 1983. However, actual launch dates that NOAA can support are currently under review. Mission operations funding will continue to support the operations and data analysis of the Solar Mesosphere Explorer and the extended Nimbus-7 mission. The Upper Atmosphere Research Satellite experiments have been selected and detailed design and development will begin in FY 1983. Spacecraft and ground data handling system definition for this mission will also continue. We have altered our planning for the Halogen Occultation Experiment from flight on the Earth Radiation Budget Satellite to flight on another spacecraft. It has been tentatively planned for inclusion in the definition of an Upper Atmosphere Research Satellite Mission.

The Technology Transfer program, which has ~~the~~ objective of transferring Landsat-type technology application to public and private organizations, is being phased out by NASA. The Congressional addition for this program in FY 1982 is being used to examine ways to transfer these efforts more systematically to the private sector. We do, however, expect to continue the most important basic research efforts on the utilization of Landsat-type technology with applied research and data analysis funds.

Our Materials Processing in Space program continues to focus on the use of the zero-g environment to obtain new insights on the basic properties of materials. The Shuttle/Spacelab Payloads Development and Material Experiment Operation budget request will provide the development of flight experiments such as the Vapor Crystal Growth System and support extensive ground based experimentation using sub-orbital flights, drop towers and drop tubes.

In Communications, the requested Applied Research and Data Analysis funding is consistent with the decision to emphasize advanced technology development which may be applicable to a wide range of future communications systems. The Search and Rescue Program will continue with the first launch in this co-operative program scheduled for 1982. Technical consultation and support studies on world-wide communication problems will continue at the previously presented FY 1982 level and the Experiment Coordination and Operation Support line will continue to support the ATS -1, -3 and -5 operation and experimentation.

In order to increase our confidence that we can achieve our technical and schedule goals during this phase of development, we plan to increase the FY 1982 funding for Space Telescope by $2.0 million. A reprogramming letter has been submitted to Congress detailing the reasons for requesting this change. The requested FY 1983 funding will support fabrication, assembly and test of the Space Telescope. This tremendously exciting project continues moving successfully toward a launch in 1985.

Requested funding for the International Solar Polar Mission will support the ESA single-spacecraft mission with NASA providing launch, tracking and several instruments. The FY 1983 funding will provide for the continued development of the U.S. instruments. These funds are also required for the development of a kick stage and interstage to accommodate the recent switch from a Shuttle/Centaur to a Shuttle/Inertial Upper Stage launch in 1986.

Requested FY 1983 funding for the Gamma Ray Observatory will provide for detailed design and initiation of flight hardware procurements. We continue to proceed toward launch in late 1988.

In the Shuttle/Spacelab Development and Mission Management area, consistent with Congressional actions, the FY 1982 funding has been increased by $5 million. This increase allows us to accelerate the first flight of the Large Format Camera. Requested funds in FY 1983 will support the development of Physics and Astronomy Instruments and also provide for the mission management activities required to support all NASA Spacelab payloads. The increased funding requested in FY 1983 reflects the fact that with the first flights of the STS having taken place we are now planning to substantially build up our Shuttle/Spacelab Payloads program.

FY 1982 Explorer development funding will support ongoing development activities of the Infrared Astronomy Satellite and lead to a launch in 1982. The FY 1983 funds will support the ongoing development of the Active Magnetospheric Particle Tracer Explorers and the Cosmic Background Explorer.

Physics and Astronomy Mission Operations and Data Analysis funding shows a slight increase over the FY 1982 Amended budget level. The FY 1982 increase is due to the inclusion of funding for repair of the Solar Maximum Mission. In December 1981, the Committees were provided an initial notification of NASA's plan to carry out the planned repair of SMM. As I will discuss later, we believe that this repair is extremely important, justifying the changes we would like to make to accommodate it. The FY 1983 request will support the required buildup in activities supporting the Space Telescope for its operations beginning in 1985 and its later maintenance and refurbishment.

Research and Analysis funding in Physics and Astronomy will continue to support fundamental research in many areas, conceptual development of possible future missions, development of the new technology required to support these missions, and extended analysis of data from past missions.

In our Physics and Astronomy suborbital program -- Sounding Rockets, Airborne Research, and Baloon flights -- we will be able to support over 50 sounding rocket flights, approximately 65 flights of the Kuiper Airborne Observatory, and approximately 20 balloon flights.

In the Planetary Exploration Program, Galileo funding in FY 1982 has been increased by $12 million over the March request to provide for the development of a kick stage and interstage to accommodate the launch on a Shuttle/Inertial Upper Stage rather than a Shuttle/Centaur as assumed in the March request. The launch vehicle change will require an Earth fly-by trajectory to pick up the necessary energy to accomplish this mission, resulting in more than two-years additional trip time and a reduction in the number of satellite encounters. A letter has been sent notifying Congress of the proposed reprogramming, and setting forth the justification for this action. The FY 1983 funding request supports continued development of the Galileo project leading to launch in 1985.

Due to the need for exercising budgetary restraint, while maintaining our highest priority space science programs, development of the Venus Orbiting Imaging Radar mission will not be undertaken at this time. We will, however, continue advanced definition efforts on concepts for a simpler Venus mapping mission with our Research and Analysis funds.

The FY 1982 Planetary Mission Operations and Data Analysis funding will support those activities absolutely necessary for Voyager and Galileo. We are considering the impact of significantly curtailing or terminating operation and data analysis for the Pioneer Venus Orbiter and Pioneers 6 through 11. Voyager operations will be continued leading to an encounter with Uranus in 1986.

Research and analysis funding will permit construction of the Infrared Telescope Mid-level Facility. We are reviewing the possibility of curtailing efforts on processing of Lunar samples, planetary astronomy and analysis of data from past missions. We may also have to stop operations of the Infrared Telescope temporarily. Firm decisions have not been reached however.

The Life Sciences Program shows some growth over the level of previous years.

Requested FY 1983 funding for Life Sciences' Shuttle/Spacelab Payloads Program will continue the development of experiments for flight on the STS that will help us understand the effects of weightlessness on man. In particular, the request will support development payloads for Spacelab 4, a mission we believe will be a key step forward in understanding medical problems associated with manned space flight.

The Life Sciences Research and Analysis Program will continue to support ground based research and future program and experiment definition.

I will turn now to a more detailed discussion of the major elements of the Space Science and Applications Program. For the remainder of my statement, I will refer to the new organizational structure in describing the contents of the program.

ASTROPHYSICS

The goal of the Astrophysics Program is to understand the origin and evolution of the universe and the fundamental laws of physics that govern cosmic phenomena. (Fig. 11) To achieve this goal, we must observe the universe in every band of electromagnetic radiation--from the shortest wavelengths of gamma radiation to the longest radio waves. Much of the spectrum is inaccessible from the ground and can only be observed from space.

Space Telescope

The Space Telescope (ST), a collaborative program with the European Space Agency (ESA), for which we are requesting $137.5 million in FY 1983, will be the flagship of the Astrophysics program. (Fig. 12) When it is launched in 1985, it will be the most powerful observatory ever built. Space Telescope will image astronomical bodies with at least ten times finer resolution than can be achieved by telescopes observing through the Earth's atmosphere, and it will detect objects fifty times fainter than the largest ground-based observatories. As a result, we will use it to attack a wide variety of frontier problems in astrophysics, particularly in the areas of extragalactic astronomy and observational cosmology.

Substantial progress has been achieved on the Space Telescope development and its focal-plane instruments. (Fig. 13) Design activity reached its peak in FY 1981, and fabrication and assembly of flight hardware has begun. Perhaps the most significant achievement has been the completion of the primary mirror. (Fig. 14) The surface departs from a perfect figure by no more than a few millionths of an inch. The primary mirror was successfully coated in December 1981, and the coating is well within specifications for both the visible and the ultraviolet. In addition, the secondary mirror was ground, polished and coated, and the two mirrors are now ready for integration into the telescope. Main structural parts for the Optical Telescope Assembly have been completed. We are now beginning the early integration process. Significant progress has been achieved in fabricating the scientific flight instruments. Design of the spacecraft Support Systems Module (SSM) is nearing completion. Spacecraft manufacturing activity for the Support Systems Module will begin after the Critical Design Review which is scheduled for March 1982.

During the past year, the Association of Universities for Research in Astronomy (AURA) was awarded a contract for management of the Space Telescope Institute. Ground was broken for its new facility at the Johns Hopkins University in Baltimore, Maryland, and staff members are being brought on board.

During FY 1982 emphasis is shifting from design to manufacturing, assembly, and testing. In FY 1983, the Optical Telescope Assembly and the Support System Module will near completion, and testing of all scientific instruments will take place.

Gamma Ray Observatory

We are developing the Gamma Ray Observatory (GRO), for which we are requesting $34.5 million in FY 1983, to explore the universe in the highest energy portion of the electromagnetic spectrum. (Fig. 15) The GRO will allow a penetrating look at the nuclear processes occurring near neutron stars and black holes and will permit investigation of the formation of elements in supernovae, the origin of gamma-ray bursts, and details of the physical nature of the recently discovered gamma-ray sources in the galaxy. The observatory will move gamma-ray astronomy from its infancy to a phase where we can begin the detailed study of the nuclear and elementary particle universe.

We have made substantial progress on this program. In FY 1981, the agency selected the mission systems contractor~~, initiated the~~ spacecraft design, confirmed four scientific instruments, and initiated the instrument development contracts. During FY 1982, we will continue spacecraft and instrument design, complete specifications for the spacecraft subsystem, and essentially complete engineering models of the instruments.

We will begin hardware development of both spacecraft and scientific instruments in FY 1983. This activity will involve procurement of long-lead hardware items, completion of a major portion of spacecraft and instrument design, and critical design reviews of most of the instruments. The Gamma Ray Observatory launch is planned for late 1988.

Infrared Astronomical Satellite

The Infrared Astronomical Satellite (IRAS) will open up a truly new frontier, the universe of cool and cold objects. (Fig. 16) In the last year, significant progress has been achieved on the IRAS, and we expect to launch it late in 1982. In FY 1981, the Dutch-built spacecraft was assembled and successfully tested, while in England the ground-tracking station has been equipped. The software for the mission has been installed and is currently under test. In the United States, the Infrared Telescope System was completely assembled and shipped to The Netherlands for integration with the spacecraft and for satellite vibration testing. After successfully passing these tests, the satellite was returned to the Jet Propulsion Laboratory in Pasadena, and environmental testing is now underway in preparation for the launch.

In the past, infrared astronomy has been conducted from mountain tops, high-flying aircraft, balloons, and sounding rockets. The early observations have shown that many celestial objects emit the bulk of their radiation at the infrared wavelengths covered by IRAS. Regions where stars are being formed, for example, often emit more radiation in the infrared than 10,000 suns emit over all wavelengths. IRAS will survey the outer solar system for asteroids -- small, minor planets with temperatures far below freezing -- and we expect it to detect thousands never before seen. Theory predicts that many burned-out stars should be detectable even though they have consumed their nuclear fuel. IRAS will give us our first road map to the interesting objects in these wavelengths.

Cosmic Background Explorer

The next addition to the Explorer series, the Cosmic Background Explorer (COBE), will be started in the second half of FY 1982. COBE will be the first satellite to be designed specifically to observe details of the Big Bang--the explosion thought to have marked the beginning of the universe. Echoes of the Big Bang were discovered in 1965 as microwave radiation coming to us from all directions of the sky. COBE will carry instruments high above the interference of the Earth's atmosphere to map this radiation at a large number of different wavelengths. The maps will help us decide whether the primeval explosion was turbulent or uniform, whether it occurred simultaneously everywhere, and how the first galaxies were formed. The resulting observations will provide fundamental new information on observational cosmology, complementing the cosmological studies from Space Telescope.

The COBE Project has completed the definition review of the spacecraft and scientific instruments. Breadboard versions of the key components and subsystems of the scientific instruments are being assembled for tests. In addition, the spacecraft system configuration has been defined, and subsystem trade-offs are being assessed. During FY 1983, the COBE project will complete the detailed design and will procure items requiring long manufacturing lead times.

Operational Satellites and Data Analysis

Nine satellites are now operating under the management of the Astrophysics division. The currently operational missions are the three International Sun-Earth Explorers (ISEE), the International Ultraviolet Explorer (IUE), and the Solar Maximum Mission (SMM). Interplanetary Monitoring Platform IMP-8, data analysis will be continued through FY 1982. The Solar Mesosphere Explorer (SME) and the pair of Dynamics Explorers (DE) are currently undergoing final post-launch check out and are scheduled to be placed into full operational status in the near future. Operation and analysis of data from IRAS will be included in this program once the satellite is launched.

Besides these active missions, we continue to support, analysis of data from the High Energy Astronomy Observatories (HEAO), the Orbiting Astronomical Observatories (OAO), and the Atmospheric Explorer (AE).

High Energy Astronomy Observatory

The High Energy Astronomy Observatory (HEAO) program has been very successful, producing many new results about a wide range of astrophysical objects. All three HEAO satellites have fully completed their mission objectives and have ceased operation. Nevertheless, analysis of data from the HEAOs continues to bring us new and dramatic information about the violent and explosive components of the universe. One of the particularly interesting results from the HEAO program is the new perspective it has given us on stars. Together with the IUE, HEAO has shown us that chromospheres, coronas and winds observed on the Sun are far more common in all types of stars than previously thought. This new perspective is leading to greater interaction between stellar astronomers and solar physicists, to the benefit of both.

Solar Maximum Mission and Solar Maximum Mission Retrieval/Repair

The Solar Maximum Mission (SMM) was launched in February 1980. (Fig. 17) It was able to operate with a fixed orientation toward the Sun until part of the attitude control system was lost in late 1980. Since that time the spacecraft has been spinning slowly with its principal axis toward the Sun so that three of the seven experiments continue to collect valuable data.

As a result of the ongoing analysis of solar flares observed by SMM, we have been able to obtain a much firmer understanding of the origin of flares. We are now certain that the energy for flares is derived from magnetic fields which emerge from the Sun's surface and form arches, about 30,000 miles across, that reach up into the corona. The collision of two field loops triggers the conversion of magnetic energy at the top of the loop into the acceleration of subatomic particles to relativistic speeds. SMM has made the first picture ever of the hard X-rays emitted when these particles strike the solar surface at the footpoints of the magnetic arch. Other observations have shown the explosive expansion of the lower atmosphere when heated by the high-speed particles and the eruption of flaring loops into giant disturbances in the outer solar corona.

In order to continue the exceptionally successful scientific progress made by SMM and to demonstrate the retrieval/repair capabilities of the Space Shuttle, we are planning an in-orbit repair of the SMM spacecraft and instruments. An astronaut, flying freely with the aid of a Manned Maneuvering Unit, will rendezvous with SMM, stabilize it, and attach a grappling device for use by the Shuttle's Remote Manipulator System (RMS). Once the RMS has taken hold of the SMM, the spacecraft will be locked into the Flight Support System in the Shuttle cargo bay where module exchange of the attitude control system and instrument repair will be performed before the spacecraft is redeployed. A repaired SMM will provide for several years of continued studies of solar flares, solar atmospheric dynamics, and the total energy output of the sun. However, we believe that the SMM repair has much broader importance than SMM itself. It will be the first demonstration of the Space Transportation System's ability to service a satellite on orbit, an important precursor to our planned operations with Space Telescope, as well as the on-orbit repair and servicing of other types of satellites.

EARTH AND PLANETARY EXPLORATION

The Earth and Planetary Exploration Program has been created by combining the Solar System Exploration Program and the (Earth) Resource Observations Program. This new program has responsibility for planetary science research for all of the planets including Earth, as well as the responsibility for continuing to pursue techniques that can materially assist us in the management and utilization of renewable and non-renewable resources. (Fig. 18) I believe that the common scientific thread that runs through all the research activities will serve to strengthen significantly the new, enlarged program. The program being presented today represents a significant restructuring in the planetary area.

Landsat-D

Landsat-D, for which we are requesting $61.7 million in FY 1983, is the latest satellite in the highly successful Landsat program. (Fig. 19) It will provide significantly improved capabilities for the remote sensing of agricultural and natural resources. The satellite's instruments have greater spectral coverage, particularly in the mid-infrared region, and improved spectral and spatial resolution over its predecessors.

During the past year the Landsat-D program has made excellent progress: the spacecraft is now in its acceptance test cycle and on schedule for a summer 1982 launch. All flight hardware elements needed to support the Landsat-D' launch have been delivered and integrated with the spacecraft. These include the Multispectral Scanner (MSS), the Thematic Mapper (TM), the Multimission Modular Spacecraft, and the Wideband Communication subsystem. Integrated operation of all elements has been satisfactorily verified without significant problems. We are particularly interested in the TM data, which may open new frontiers of data applications in remote sensing in the coming years.

Progress in the Landsat ground segment development during the past year has been significant. All data processing hardware elements have been integrated into the various ground segment facilities needed to support the launch. These include the Control and Simulation Facility which will control the spacecraft, the mission management facility which will control the many operations of the entire ground complex, the Image Generation Facility which will process the MSS data into geometrically and radiometrically corrected data products, and the Landsat Assessment System which will be used to verify the quality of the Landsat data products and assess their utility for improved data extraction techniques. Development and integration of the data processing software is nearing completion.

During FY 1983, Landsat-D MSS operations and the distribution of MSS data products will be initiated. The TM data processing system will build up from a capability of handling one scene per day at the Landsat-D launch date to 12 scenes per day by mid-1983. During the first year of Landsat-D operations, the TM orbital performance will be characterized. The 50 scenes per day TM requirement should be achieved by early 1985.

During FY 1983, the Landsat-D' spacecraft will be integrated and launch readiness testing completed. If not needed as back-up for Landsat-D, it will be placed in storage and launched after the Landsat-D operational lifetime.

NASA currently plans to turn over control of the Landsat-D spacecraft and MSS data processing to NOAA six months after launch. TM data processing and TM R&D responsibility will remain with NASA until the system is considered fully operational. The details of the turnover are still being negotiated with NOAA.

Landsat Utilization

There continues to be widespread use of Landsat data. For example, in FY 1981, Applications Systems Verification and Test (ASVT) projects were completed with the National Park Service; with the States of Washington, Idaho and Oregon and the Pacific Northwest Regional Commission; and with the State of Texas. The States of Washington, Idaho, Oregon, and Texas have already established operational Landsat data processing systems, and the National Park Service has requested funding for such a system at its Denver Service Center. ASVT projects with Pacific Gas and Electric, Florida Water Management Districts, and the States of Alaska and California will be completed in FY 1982. These projects have shown that Landsat data when combined with data from other sources, can provide a capability greater than that previously available.

Nationally, a growing community of users of Landsat data is emerging. "A Survey of State Applications of, and Investments in, Landsat Technology" published by the National Conference of State Legislatures and the Council of State Planning Agencies in May, 1981 jointly reported that 26 states have developed, or are developing capabilities to use Landsat data. Approximately 400 applications are defined by states as routine and continuous. State investments include $28 million of expenditures (not including personnel costs) since the first satellite was launched in 1972 of which $5 million were expended specifically for the acquisition of software and hardware.

In FY 1983, we will continue grants to fourteen universities to conduct discipline-oriented research in space applications, and to test and evaluate remote sensing techniques. This funding will maintain centers for the development, test and evaluation of new remote sensing technology, such as the Thematic Mapper, together with centers for basic and applied research in geology, geodynamics and materials processing.

AgRISTARS (Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing)

AgRISTARS is a program of research, development and testing which deals with the management of domestic resources and the provision of information on the global condition and production of commodities. The program is conducted in cooperation with the U.S. Department of Agriculture (USDA) and NOAA, with support from the Department of the Interior, to serve the program needs of USDA. We are requesting $15.0 million in FY 1983 to continue to support AgRISTARS in selected research and development activities requiring NASA's specialized capability. Since NASA is only one of the several agencies implementing the total AgRISTARS program, our activities must be undertaken in consonance with the FY 1983 plans of the other agencies. While coordination is not yet complete, it is clear that presently planned program schedules and the program scope will have to be modified. As part of the program restructuring, responsibility for the pilot testing activity will be terminated by NASA under the assumption that the Department of Agriculture will pickup the efforts. Discussions concerning the future of the program are currently underway with USDA.

Automated techniques for the analysis of Landsat data have progressed to the point where analysis and computer processing times are no longer significant limitations to the efficient use of the technology. Substantial progress also has been made in our ability to separate the signature of small grains, particularly corn and soybeans at or near harvest. The improved capability available with the Thematic Mapper holds promise of much improved separability of corn and soybeans at earlier growth stages, and for accommodating a wider range of agricultural conditions. Research in quantifying the impact of abnormal weather conditions on crop yield has produced models for estimating losses occurring when rain falls during wheat harvest, and the effect of hot dry winds on crop yield.

Some specific objectives to be addressed during the FY 1982-83 period include: completion of a multiple crop technique development activity; continued research on classification techniques emphasizing spatial information; continued research on understanding the physical processes that influence reflected or emitted energy from scene elements; and, continued development of a statistical theory for sampling remotely sensed data.

Geodynamics

We are requesting $26.2 million in FY 1983 to continue studies of the solid Earth including movement and deformation of the crust; gravity and magnetic fields; and rotational dynamics. These studies contribute to our understanding of crustal hazards such as earthquakes, and are important in understanding how the Earth is evolving and how the solid Earth interacts with the oceans and the atmosphere.

The Earth's lithosphere consists of roughly seven major continental-sized blocks or plates a few hundred kilometers thick, and a number of smaller plates, all of which are moving with respect to one another at rates up to 15 centimeters per year. The plates move almost as rigid bodies, but the tiny deformations where they are in contact are largely responsible for earthquakes, mountain building, and other geological phenomena.

We first began to measure the relative movement of the Pacific and North American plates in 1972 using laser ranging to satellites from opposite sides of the San Andreas Fault. These measurements have been made every two years since that time, most recently in 1981. Over this ten year span the relative motion along the San Andreas Fault averages about 8 cm/year, far in excess of the 5.5 cm/year predicted by global geological and geophysical evidence. To explain these discrepancies, the density of measurements along the San Andreas Fault System was increased this past year. We currently plan to repeat these measurements each year through 1987, to determine the rate of deformation between sites and to develop a model of crustal strain accumulation associated with the San Andreas Fault System. Similar studies of crustal deformation in Alaska and joint studies of Pacific plate motions with Japan have been delayed.

Monitoring of the dynamical motion of the Earth about its axis of rotation over the past 100 years has established that the Earth's polar axis wanders over a roughly circular path with a mean diameter of 10-15 meters and that the length of day varies by several milliseconds per day. While much is known about the gross nature of these motions, the physical explanations have escaped us because of limitations on the accuracy of observations. The improved accuracy available with laser and microwave interferometric techniques (about 10 cm), now are providing definitive evidence of short period variations in polar motion. Variations in length of day have been correlated with changes in the total angular momentum of the upper atmosphere. When the atmospheric effects were subtracted from observed Earth rotation measurements, a previously unknown periodicity of 50 days in the variation of the Earth's rotation rate was discovered. This periodicity is being studied in order to identify its origin.

The Geodynamics Program is being coordinated through formal agreements with other Federal Agencies (NOAA, USGS, NSF, and DMA) and we are participating in international programs to use space technology for global studies of geodynamics. Within the United States, three new geodetic services using space methods are being planned: a National Crustal Motion Network by NOAA, beginning in 1984; an improved Polar Motion and Earth Rotation Service (Polaris) jointly developed by NASA and NOAA to be operational in 1983; and a Local Crustal Motion Network monitored by the USGS using the DOD Global Positioning System.

Galileo

I will turn now to our solar system exploration program by discussing the Galileo Mission to Jupiter which remains the centerpiece of the planetary part of our program. The Galileo mission, for which we are requesting $92.6 million in FY 1983, will carry out a thorough exploration of the giant planet Jupiter, following up on the Voyager discoveries. The mission consists of an orbiter that will provide imaging, remote sensing and magnetospheric measurements of Jupiter and its satellites. In addition, an atmospheric probe will obtain in situ measurements of Jupiter's chemical composition and physical state. (Fig. 20)

Our plans for completion of the Galileo mission, a cooperative mission with the Federal Republic of Germany, have been changed. We now plan to launch the combined Galileo orbiter and probe using a Shuttle/Inertial Upper Stage plus an auxiliary kick stage instead of a Shuttle/Centaur launch. The major change in the mission will be the type of trajectory used to reach Jupiter. Approximately one year after launch, an apogee burn will be performed by the spacecraft kick stage to properly target the spacecraft to re-encounter the Earth for a gravity assist in mid-1987. The spacecraft will then proceed on its transit to Jupiter, arriving in early 1990.

Critical Design Reviews for both Orbiter and Probe systems as well as all subsystem and component levels have been completed, and flight hardware production is underway on almost all elements. (Fig. 21) A substantial amount of hardware has, in fact, already been delivered. The new launch strategy is designed to minimize the impact to the development program by allowing development of orbiter and probe spacecraft to continue unchanged. The only new element is the addition of the kick stage and interstage development. The cost estimate for the kick stage and the associated mission modifications are under review. The cost and schedule for all other elements are virtually unchanged from the 1985 Centaur launch.

The Galileo mission has been designed to return the maximum amount of information possible. The 1985 mission takes full advantage of the funds obligated to date and preserves the complete scientific potential of the mission. Although we have had interruptions in the development of this mission, we continue to make substantial progress and our German partners remain committed to the mission.

International Solar Polar Mission

The cancellation of the U.S. spacecraft portion of the International Solar Polar Mission (ISPM) has now been fully implemented. We are still fully supporting the remaining European spacecraft (Fig. 22) and the U.S. experiments carried as part of its payload. A special study conducted by the National Academy of Sciences in the summer of 1981 confirmed that a single spacecraft mission would perform a valuable first reconnaissance of interplanetary phenomena far from the Sun's equatorial plane and of the three-dimensional properties of the solar wind.

The ISPM payload contains nine separate investigations of which five have U.S. principal investigators. Of the 79 principal and co-investigators still involved, 29 are from the United States. Three of the four European investigations have U.S. co-investigators. Thus, the U.S. scientific involvement is substantial. In addition, the United States will provide the radioactive thermal power generator, launch services and tracking and data acquisition for the mission.

The launch of the ISPM spacecraft will utilize the Shuttle/Inertial Upper Stage (IUS) augmented by an auxiliary propulsion system (kick stage and interstage). This is a change from our last testimony. The development of the kick stage and interstage, supported by this budget request, will be initiated in FY 1982 and will be continued in FY 1983 leading to a launch in 1986.

We are also looking at the possibility of providing in-ecliptic support to the International Solar Polar Mission. In particular, we are interested in seeing whether there is a way of flying appropriate imaging instrumentation in Earth orbit so that the particles and fields phenomena measured by the ESA spacecraft can be traced back to the sun, thereby recovering the capability of making the most important measurements now missing from the mission.

Operational Spacecraft

The operational spacecraft include the Voyagers, the Pioneer Venus Orbiter, Pioneers 6-11, the Viking 1 Lander and Landsat-3. FY 1983 funds for extended Landsat operations will support the continuation of remotely-sensed multispectral and high resolution imagery of the Earth's surface by Landsat-3. In February, Landsat-2 experienced difficulty with its attitude control system and was removed from operational service but it is being monitored for engineering purposes. We currently are reviewing the possibility of terminating all Pioneer spacecraft operations in order to provide adequate support to our ongoing high priority projects.

The Pioneer Venus Orbiter continues to acquire data from the planet Venus. Recently, a comprehensive story has emerged of Venus' cloud system which appears to be a diffuse sulfuric acid (H_2SO_4) smog layer above patchy, condensational H_2SO_4 clouds. There are many new pictures of Venus' cloud motions which have been made into a first movie of Venus' cloud rotation, showing long term circulation. Global atmosphere computer modeling, capable of reproducing atmosphere motions, is now being undertaken using these real data on cloud top dynamics. The radar altimeter map of the Venusian surface, showing continental scale geological features has been completed. The slowly changing orbit of the Pioneer Venus spacecraft also has permitted the interactions of the solar wind with Venus' ionosphere to be mapped through new regions for the study of ionosphere structure and composition.

Pioneers 10 and 11 continue their journey through the outer reaches of the solar system. By the end of 1981, Pioneer 10 was 3.9 billion km from the Sun, closing on the orbit of Neptune. This significant achievement demonstrated that the boundary of the heliosphere is farther from the Sun than had been previously predicted. Pioneer 11, moving in the opposite direction out of the solar system, was 1.7 billion km from our Sun. Both spacecraft continue to acquire direct measurements of solar and galactic phenomena in interplanetary space.

The Viking Lander-1, renamed the Mutch Memorial Station, in honor of the former Associate Administrator for Space Science, Thomas Mutch, continues to acquire seasonal meteorology and imaging data, as well as engineering information from the surface of Mars. The Lander, the last of four spacecraft which arrived at Mars in 1976, is programmed to acquire data until December 1994.

Halley Comet Watch and Experiments

American scientific expertise is well represented on the European Space Agency's Giotto mission to Comet Halley. Nine of the ten instruments in the payload have U.S. co-investigators with a total of 32 American scientists involved. The U.S. support provides mostly for consultation, limited design effort and some instrument calibration activities by the U.S. scientists. The critical hardware expertise for the Ion Mass Spectrometer resides in the United States and a major section of the instrument is being designed and fabricated here. It is obvious that the input of American scientists is important to the Giotto mission. In addition to participation on instrument teams, American scientists are supported also in the areas of cometary dust modeling and comet trajectory calculations, both of which are critical areas to the mission. The FY 1983 funding will continue the American scientists' involvement in the Giotto mission.

In FY 1982 organization of the International Halley Comet Watch was initiated. (Fig. 23) A European co-leader of the Watch has been appointed to share management responsibilities with the U.S. leader. A steering group has been established with half non-U.S. membership, including representatives from the Soviet Union and Japan. Several worldwide networks of ground-based observatories are to be established to provide around-the-clock coverage of the comet with wide-angle imaging, spectroscopy, photometry, and other types of observations. Each network will be jointly managed by a U.S. scientist and his non-U.S. counterpart. The FY 1983 funding will be used to initiate the establishment of the international observing networks.

ENVIRONMENTAL OBSERVATIONS

The Environmental Observations Program, as its name implies, is concerned with the Earth's environment. (Fig. 24) The environment begins with the solar wind as it approaches the Earth and encompasses the magnetosphere and its enclosed plasma, the ionosphere, the atmosphere, and the oceans. In the recent NASA reorganization, studies of the magnetosphere, ionosphere, and the solar wind as the driver of the terrestrial environment, were added to this program. The resulting integrated approach to the study of the environment will improve NASA's ability to study and understand comprehensive questions of Sun-Earth relations and climate. All of the phenomena of this program--whether in meteorology, oceanography, aeronomy or plasma physics--are dynamic and ever changing. Thus, we require a program which not only strives to measure present conditions but works to understand how the environment responds to change, and to forecast its future evolution. The ability to forecast has potential benefits for mankind ranging from weather and storm prediction to providing the scientific basis for environmental and energy-use policy decisions. The elements of the program are at different states of maturity ranging from the well-developed use of space to observe the interplanetary medium, thermosphere, magnetosphere and weather phenomena to the more pioneering efforts to use remote sensing to measure the chemical composition of the upper atmosphere and the state of the global ocean and its circulation.

The program is coordinated to further our understanding of the individual components of the environment and how they interrelate. The goal is ultimately to obtain a comprehensive picture of how the energy from the Sun passes through and interacts with the intervening media to drive the dynamic environment of Earth and of how we influence the evolution of this system.

Active Magnetospheric Particle Tracer Explorers

Energy reaches the Earth in the form of plasma in the solar winds. A crucial area of study is how this plasma is transported and accelerated in the magnetosphere. One step toward finding the answer is the Active Magnetospheric Particle Tracer Explorers (AMPTE), which were initiated in 1981. This mission is a two-spacecraft project being developed in cooperation with the Federal Republic of Germany. The Ion Release Module provided by our German partners will release barium and lithium at several locations inside and outside the magnetosphere. After each release, the Charge Composition Explorer which is being provided by the United States will attempt to detect the released particles from inside the magnetosphere. Throughout FY 1982, design of the spacecraft and the instrument complement will be completed and a critical design review held. During FY 1983, fabrication of the spacecraft and the instrument complement will be completed. Instrument delivery is scheduled for mid- 1983, with launch planned for 1984.

Upper Atmospheric Research Satellite Mission Definition

Below the magnetosphere is the Earth's upper atmosphere, a vital link in the environmental system. Global observations of the chemical composition, dynamics and energetics of the upper atmosphere are being planned for study by a possible Upper Atmospheric Research Satellite (UARS) mission. (Fig. 25) These measurements are required before we can adequately understand this region of the environment and make improved projections of the impact of human activity on the stratospheric ozone layer.

We have completed a major step in the UARS experiments activity with the final selection of nine principal investigator research instruments and an operational Stratospheric Backscatter Ultraviolet (SBUV) instrument to be carried on the mission. Ten supporting theoretical investigations also have been chosen to provide numerical modeling tools and data analysis techniques. Integration of these activities into the program will ensure the maximum return from the mission. All of the instruments have completed design definition. We are currently assembling the components necessary to test certain critical areas of instrument design. This will be followed by detailed design for both the instruments and their interface to the spacecraft. The requested funding of $14.0 million will support continuation of these activities in FY 1983.

Earth Radiation Budget Experiment

Many of the essential features of the climate on Earth are determined by the flow of energy in the natural environment. Energy, primarily in the form of radiation from the Sun, is incident on the Earth. Some of that energy is reflected back to space. The remainder is transformed and redistributed by the dynamic processes in the atmosphere and oceans. Detailed understanding of these processes is essential to our ability to comprehend the mechanisms which determine the climate. As a major step in achieving this scientific understanding, the Earth Radiation Budget Experiment (ERBE) will measure how the absorption and emission of energy are distributed over the Earth. (Fig. 26) This measurement will be accomplished using identical earth radiation budget instruments on three different satellites: two polar orbiting NOAA satellites--NOAA-F and G--and a dedicated NASA satellite which will be in a more nearly equatorial orbit. The polar orbiters will provide global coverage but at only one time of day. The lower inclination satellite will provide measurements of change in the radiation budget over the day-night cycle. The dedicated NASA satellite will also carry a Stratospheric Aerosols and Gas Experiment (SAGE) to measure the particle content of the upper atmosphere. Completion and delivery of the instruments will be the major activity in FY 1983, to be supported by the request of $24.0 million. The launch date is under review, pending final determination of the NOAA polar orbiter satellite launch schedule and the availability of space on the STS. Maintenance of current schedules for instrument delivery should, however, minimize the financial impact of a change in the launch schedule.

Nimbus and Operational Satellites

Useful data continue to pour in from the Nimbus-7 satellite. Electric Scanning Microwave Radiometer (ESMR) data from Nimbus-5 are still being obtained and used by the Navy. After two and a half productive years the SAGE satellite has ceased operating, but data reduction will continue into FY 1983. The Environmental Observations program is continuing to support the development, procurement and launch of the NOAA operational weather satellites on a reimbursable basis. However, NASA funding for the Operational Satellite Improvement Program will be phased out after completion of the current development of the operational Stratospheric Backscatter Ultraviolet instrument for the NOAA satellites and other ongoing tasks.

Upper Atmospheric Research

Since 1976, NASA has carried out a program of Upper Atmospheric Research. This program is designed to improve our understanding of the stratosphere and to produce scientific assessments of the probable threat to the ozone layer from chlorofluorocarbons and other residual substances introduced into the atmosphere by human activity. Under this program, laboratory measurements are made of the rates of chemical reactions involving stratospheric constituents. This information is included in predictive models of the upper atmosphere chemistry and is used in the design of new measurement techniques. Observations are made from a variety of suborbital platforms to determine the processes at work in the stratosphere. Satellite measurements provide the global data needed to determine the distribution of ozone and other chemicals and the circulation of the upper atmosphere. Models are being developed to quantify our understanding of these processes and to make assessments of the ozone layer response to external changes.

The necessity to carry out all of these different activities has been demonstrated by the latest assessment of ozone depletion due to chlorofluorocarbons submitted to the Congress in January. Laboratory measurements have determined new values for the rates of chemical reactions important in controlling ozone destruction in the lower stratosphere. These new values were included in the models and resulted in a new prediction for eventual ozone depletion of 5 to 9 percent. This is substantially less than the previous assessment finding of 15 to 18 percent. The models also were used to calculate the distribution of the various chemical constituents of the stratosphere. These model results were compared with our suborbital measurements and there is greater agreement than in the past. The models can be run retrospectively as well as prospectively to produce a calculated history of ozone concentration. Such calculations have been compared with the satellite data record which now extends over most of the last ten years. The predictions and the data record are now consistent. Lack of such consistency had been raised as an objection to the earlier assessment.

Over the past year, our program in tropospheric air quality has demonstrated the usefulness of geostationary satellite images for detection and tracking of large scale air masses. These pictures reveal the regional and global aspect of air pollution. Theoretical studies have shown the prevalence of long range transport of sulfur oxides from urban areas. These findings show the importance of approaching tropospheric air chemistry from a global perspective. This will be one key element in our continuing program; another element is understanding the global troposphere as a source and sink for trace gases in the upper atmosphere. NASA will continue to explore promising new techniques for sensing tropospheric composition from space and the role that tropospheric chemical composition plays in global ecology.

Weather, Climate & Severe Storms

In the lower atmosphere, the energy from the Sun affects atmospheric dynamics and radiation. This area of research has as its goal the understanding and prediction of the full range of weather phenomena and the climate. (Fig. 27) In the past year, satellite data use has permitted the extension of reliable weather forecasts from three to five days. Analysis of data from the Global Weather Experiment of the international Global Atmospheric Research Program has clarified our understanding of what types of data are necessary for further extensions of forecast capability. In particular, it is now clear that the conventional observing system of ground-based observations and balloons will never be adequate to permit reliable five day forecasts. Tropical data, which are only available from space observations, are needed for long-range forecasts over the United States. Forecasts of the basic weather patterns eight to ten days in advance will require measurements of winds such as those which are now available from cloud tracking in satellite images.

Light detection and ranging (LIDAR) techniques appear to hold great promise for improving the measurement of atmospheric temperature, pressure and winds. (Fig. 28) Ground based experiments have now achieved temperature accuracies of 1 °C and pressure accuracies of 3 millibars. An aircraft doppler LIDAR instrument for remotely measuring winds has had its initial test flight and was highly successful. In FY 1983, these activities will be extended. In particular, a LIDAR temperature and pressure sounder instrument will be built and tested on aircraft flights.

The Climate program requires data obtained over long time periods to determine the trends in the various aspects of our environment and to determine the causes and predictability. Accurate measurements of this type have begun for solar irradiance using instruments carried on the Nimbus-7 and Solar Maximum Mission spacecraft. These observations have revealed a natural variability in solar output of 0.2% on time scales as short as one week. This finding implies that continuous viewing of the Sun will be required to determine if the solar energy input to the Earth is changing over long periods of time.

The first two years of measurements of stratospheric aerosols have now been added to our climate data base. These measurements continue to come in from the SAM II experiment on Nimbus-7. Efforts are underway to establish the climatology of polar stratospheric clouds and antarctic sea ice. NASA is playing a key role in planning the World Meteorological Organization's International Satellite Cloud Climatology Project. Each of these efforts provides a vital subset of data for the climate data base.

Large numerical models play a central role in all of the scientific investigations in the general area of weather and climate. They are essential for accurate predictions. The growing capability of these models requires a new advanced computer. The High Speed Vector Processor that has been ordered to meet this need starting in FY 1983 and should enable advances in models ranging from the mesoscale of storm systems to those of the global circulation and climate. The facility will also be used by the other programs in environmental observations projects.

Oceans Processes

The last part of the environment which can respond dynamically to the input of energy from space is the global ocean. A key feature of this response appears as the circulation of the oceans. Determining this circulation in detail has emerged as the central thrust of NASA's efforts in oceanography.

During the past year the oceans program has been restructured following the cancellation of the NOSS project. The community's perceived value of ocean remote sensing, as demonstrated by Seasat and by the Coastal Zone Color Scanner (CZCS) and microwave radiometer on Nimbus-7, continues to grow. Nimbus-7 data is now routinely processed without any backlogs. During the past year, all Seasat data were archived at NOAA. The data contain seasurface temperature to better than 1 °C over selected broad regions; observations of ocean chlorophyll concentration to 30% accuracy over a range of two orders of magnitude in concentration; and, improved measurements of the marine geoid. The altimeter data have also provided a determination of the global variability of the major ocean current systems over the three-month lifetime of Seasat.

In FY 1983, we will continue to take advantage of the existing data sets. An atlas containing overlays of the various Seasat data sets will be published. The utility of these data for studies of polar ice will be assessed. A chlorophyll atlas also will be published. Other efforts will address improving our capability to observe the ocean from space. Since only the surface of the oceans can be observed from space, this necessitates the development of in-situ sensors to reveal the three-dimensional structure of the ocean. Development of such sensors using satellite data relays for gathering this information will be another thrust of the program in the coming year.

The central challenge facing our oceans program now is to develop new space tools to provide the requisite data to improve our understanding of this part of the environment. In addition to an Ocean Topography Experiment (TOPEX) being discussed as a possible dedicated future space mission, the possibility of flying ocean sensors piggy-back on other missions is being examined. This is a low-cost approach for obtaining the needed ocean measurements. This approach appears to be feasible, particularly for the flight of scatterometers and ocean color scanners.

LIFE SCIENCES

In FY 1983 we are requesting $31.7 million for continuation of our Life Sciences Research and Analysis program and $24.0 million for Spacelab flight experiment development.

The resumption of U.S. manned space missions has brought into focus the need for updated medical procedures to cope with the changes that have occurred since the Apollo flights. (Fig. 29) For the first time crew member specialization has required NASA to develop medical standards specific for individual classes of STS crew members. Both STS-1 and STS-2 crews demonstrated good health as they carried out their missions. However, these flights have raised concerns about work-rest cycles, crew time lines, and inflight food and water palatability.

Past U.S. and Soviet experience has shown that nearly 40 percent of all individuals flown in space have experienced motion sickness, and almost all crewmen flown beyond 24 hours have experienced some degree of cardiovascular and muscular deconditioning. On STS-2, the testing of a newly developed lightweight exercise treadmill was initiated. However, due to the shortened mission, the full range of exercise protocols was not tested. Tests will continue on future missions. During FY 1983, newer drugs aimed at decreasing postflight cardiovascular deconditioning will be tested in ground-based simulations of weightlessness.

Among the several important technical advances investigators have made in addressing these problems has been the development of a device for imaging the movements of the heart. Investigators have also recently achieved the first success in visualizing coronary arteries from intravenous angiograms using computer enhancement techniques. The vastly decreased risks of intravenous angiography compared to the conventional injection of a dye into an artery promises to provide an acceptable screening procedure for prospective spaceflight crewmembers and passengers.

A study of vestibular test procedures and protocols to predict individual susceptibility to space motion sickness was initiated with the first STS flight. The usefulness of biofeedback-like training in suppressing motion sickness symptoms continues to show promise and, based on the observation that it is possible to suppress the vestibular ocular reflex by fixation, the ability to control motion sickness symptoms through this maneuver is also being investigated. The potential benefits of such motion sickness studies to the many people who are susceptible to motion sickness are very high.

The advent of Space Shuttle has brought renewed attention to the development of technology to support human crews in space. Over the past few years, we have developed components and technology for a space suit that can operate with a higher internal atmospheric pressure so that astronauts using it will not have to breathe pure oxygen for several hours before donning it to work in space.

Our laboratory research program is complemented by a Life Sciences Flight Experiments Program which has as its focus investigations that address the safety, well-being, and productivity of man in space, and that can only be carried out in the space environment itself. A secondary goal involves the use of space to further man's understanding of fundamental problems in gravitational biology. Current flight activities include use of small plant growth units on the Shuttle Flight Test missions, seven medical and biological experiments on Spacelab-1, two investigations on Spacelab-2, and a number of important hardware tests on Spacelab-3 which will pave the way to the Spacelab-4 mission discussed later.

With access to the unique space environment, we can now study fundamental mechanisms of physiological changes that occur in both animals and plants in weightlessness. Flight experiment results have shown that our weightless simulation models do indeed mimic bone and cardiovascular changes observed during flight. In addition, research with plant gravity sensors is providing insight into plant growth and control.

In addition to the foregoing research programs which emphasize the health and well being of space crews and the use of the space environment as a laboratory, the Life Sciences program carries out investigations of terrestrial biology. For example, in pursuit of NASA's charter to understand the origin of the universe, ground-based simulations as well as observations and exploration of extraterrestrial environments indicate that the origin and evolution of life is inseparably linked with those processes that shaped the origin and evolution of the universe itself. Studies of ancient rocks have revealed well-preserved microfossils which have pushed back the time for the origin of life on Earth to a point earlier than 3.5 billion years ago. In addition, comparison of these ancient microbes with the characteristics of their modern-day counterparts, an objective of the FY 1983 program, will lead to a better understanding of the composition of the early atmosphere with which these organisms interacted.

SPACELAB FLIGHT

The first Shuttle flights have opened the prospect of an era of new capabilities in our space science and applications program. In particular the Shuttle/Spacelab system offers to the space science, applications and technology disciplines the unique capabilities of large payload capacity; return of flight experiment hardware, film, materials processing samples, and life sciences specimens; active manned operations; and repetitive access to space. An active Spacelab utilization program is being implemented to take maximum advantage of these capabilities. (Fig. 30) Programs now underway span an impressive spectrum of research, as even a brief summary demonstrates.

The flight of OSTA-1 in 1981 amply demonstrated the Shuttle's capability for scientific and applications research. OSTA-1 was the first step in our attempt to learn how to take advantage of the Space Shuttle. Scientific data were returned, and experience was gained in the design, construction and integration of a scientific payload. When the flight was shortened, the team of OSTA-1 investigators and flight controllers demonstrated their capability to replan the mission quickly and effectively in order to accomplish the mission objectives.

The third flight of the Space Shuttle carried a scientific payload. The OSS-1 payload, launched on March 22, 1982, is a single pallet containing nine scientific instruments used to carry out science investigations and to evaluate the effects of the Shuttle on scientific measurements. Investigations in plasma physics, solar physics, planetary physics, astronomy and life sciences were performed. Each flight is providing valuable experience on learning how to use the Shuttle as a scientific tool in addition to performing important scientific experiments. We are just beginning to evaluate the scientific results from the flight and look forward to a future opportunity to share these results with you.

We continue to make substantial progress on other missions as well. Spacelab 1, a cooperative mission between NASA and the European Space Agency (ESA), will be the first flight of the module-plus-pallet configuration of Spacelab. There are eighty-one individual investigations on the mission, covering the discipline areas of plasma physics, solar physics, astronomy, atmospheric physics, Earth observations, material sciences and life sciences. Integration of the ESA portion of the science payload is almost complete with delivery to the United States scheduled in mid-1982. The NASA portion of the payload is now being delivered. Launch is planned for late 1983.

We are in the final stages of establishing our Spacelab Ground Processing Operations support facilities at the Kennedy Space Center (KSC). The processing capability includes modifications to the operations and checkout building and the development of ground test and support equipment. The processing, equipment, software and procedures are on schedule to support the ground processing of Spacelab 1, which is to begin in March 1982.

Additional missions are also in various stages of development. For instance, OSTA-2, a cooperative materials processing mission with the Federal Republic of Germany, is tentatively scheduled for flight in early 1983. It will be the first flight of the Materials Experiment Assembly, with reflight planned for late 1983.

The OSTA-3 payload is planned to be flown as part of the STS-16 mission in 1984. The OSTA-3 payload will include the Large Format Camera and its associated Attitude Reference System for acquiring high resolution mapping quality photographs with black and white, color and color infrared film. In addition, we are considering flying an upgraded version of the highly-successful Shuttle Imaging Radar to acquire imagery for a broader range of investigations in geology, agriculture, hydrology, and ocean ice.

Spacelab 2, the second dedicated Spacelab mission, will carry out scientific investigations in the areas of solar physics, high energy astrophysics, infrared astronomy, plasma physics, life sciences, and space technology. Twelve instruments, two of which are from the United Kingdom, will be flown. The mission, which is currently scheduled for a late November 1984 launch, will be a verification flight of the all-pallet/Igloo Spacelab configuration with the ESA-developed Instrument Pointing System (IPS) flying for the first time. Assembly and test for most of the Spacelab 2 instruments will be completed in 1982.

Spacelab 3 will be the third dedicated mission and will employ the module as a manned laboratory for performing experiments in the disciplines of materials processing, life sciences and technology. Low gravity investigations will be emphasized. Work on the Fluid Experiments Systems/Vapor Crystal Growth (FES/VCG) will continue through ground rack integration and then be taken to Marshall Space Flight Center for final testing and integration. Two instruments to be used for environmental observations and cosmic ray measurements will be mounted on a special structure inside the payload bay. Initial design of the integrated payload was completed in 1981. Final design is expected to be completed in 1982, leading to a launch in 1984.

Spacelab 4 will be the first life sciences dedicated mission and is planned for launch in late 1985. Twenty-five investigations have been tentatively selected as the payload for this mission. The scientific objective of this payload is the study of the acute effects of weightless exposure on living systems. There is a general emphasis on the gathering of more extensive data on previously observed physiological changes in humans and on developing animal models of the major human changes associated with weightlessness.

The OSS-3 pallet, now in development for flight in 1985, will represent our first major step in a shuttle based ultraviolet astronomy program. These instruments, which have been carefully selected to complement Space Telescope capabilities, will observe various astronomical objects, such as intrinsically polarized stars, quasars, active nuclei of galaxies, and globular clusters. In late 1985 through early 1986, Halley's Comet will make one of its once-in-a-lifetime appearances. To take advantage of this event, plans are being made to observe the comet in ultraviolet wavelengths from the Space Shuttle using the cluster of telescopes currently under development for the OSS-3 mission.

In addition to the smaller investigator-developed instruments, the Solar Optical Telescope (SOT) will be developed. The SOT is planned to be a 1.2-meter aperture telescope intended to be carried on several Spacelab flights in the late 1980's for ultra-high resolution studies of the Sun at near infrared, visible and ultraviolet wavelengths. Solar features as small as 80 kilometers across will be observed routinely with this telescope, a performance five times better than the best ground-based solar telescopes can achieve even under rare, ideal observing conditions. SOT will study time-varying phenomena of small solar features such as the fine structures of the chromosphere, magnetic flux ropes, spicules and flare sites. The focal plane instruments which we plan to fly on SOT were selected for definition in September of 1981. They are a combination spectrograph and tunable filter system and a wide-angle film imaging system. The spectrograph will cover both the visible and ultraviolet regions of the solar spectrum, permitting accurate measurements of magnetic field strengths, and permitting us to detect the vertical motions of the plasma of the Sun's atmosphere over a wide range of temperature. The imaging instruments will complement this capability by providing two-dimensional pictures of the structures of the Sun's surface with velocity and magnetic field information.

MATERIALS PROCESSING

The Materials Processing in Space (MPS) program seeks to exploit the low-gravity environment of near Earth orbit to ascertain and understand the role of gravity in materials processing, and where possible, to demonstrate the production of improved materials which have high technological utility. (Fig. 31) Major emphasis continues in establishing a sound scientific foundation through our Applied Research and Data Analysis program for these activities. Materials Experiment Operations, which will continue to provide ground based, short term, low gravity, experimental opportunities, will be augmented this year by our first opportunities for experimentation aboard STS. The Monodisperse Latex Reactor (MLR), designed to produce highly uniform latex spheres, is a payload which will be mounted in the Shuttle crew cabin. The MLR has flown on the third shuttle flight and is scheduled for additional flights on the fourth, fifth and sixth Shuttle missions.

The ground and airborne low-g based facilities continue to provide not only the necessary testing opportunities for future STS experiments, but new and important scientific information as well. Last year, drop tube experiments showed that a compound of niobium and germanium, known for its superconducting properties, could be supercooled by 500°C below its normal melting point during free fall, indicating a potential for the production of new, metastable materials by this method. Studies utilizing the low-g parabolic flight of a KC

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135 aircraft have also shown that decreasing gravity leads to increases in the grain size of castings, indicating the role of gravity-driven convective flow in establishing the microstructure of materials.

Space Processing Application Rocket (SPAR) experiments flown in 1981 showed that an eutectic (minimum melting point) composition of manganese and bismuth has substantially different microstructure when solidified at low-g compared to that at 1-g. This result, unexpected and still unexplained by conventional theory, is another example of how important contributions can be made to materials science by low-g research.

The McDonnell-Douglas (MDAC) Joint Endeavor Agreement (JEA) for the separation of biologicals in low-g has proceeded through design and testing of hardware (a MDAC funded effort) and will have the first of its six planned Shuttle Mid-deck flights on STS-4 during 1982. A new JEA has been signed with the GTI Corporation which will provide small samples solidified in low gravity to university and industrial researchers. Negotiations for the third MPS JEA proposed by Microgravity Research Associates Corporation are expected in early 1982. The first Technical Exchange Agreement (TEA) was signed in August 1981, with John Deere and Company and will provide cooperative NASA/Industry research efforts in the study of convection efforts in cast iron microstructure. Two additional TEA's with Du Pont Corporation and INCO Research and Development, were signed in January 1982.

COMMUNICATIONS

NASA is continuing its efforts in the development of high risk technology required to ensure continued U.S. preeminence in the important field of satellite communications. (Fig. 32) The currently allocated spectrum bands for satellite use are becoming saturated under the demand for commercial systems. NASA, in a joint program with U.S. industry, is developing technology designed to directly alleviate the inevitable saturation of the currently used orbit and spectrum which will occur by the early 1990's. Emphasis in the program will be on Advanced Communication Satellite research and development. The technology developed under this program will be usable in multiple frequency bands and will be applicable to a wide range of future communications systems required by NASA, other government agencies and U.S. industry. We are also currently investigating the best way to conduct a system level test and evaluation mission which will meet these objectives and regain U.S. pre-eminence in this important industry. The Search and Rescue Satellite Program is progressing satisfactorily toward a first launch on the NOAA-E spacecraft in 1983. Studies that explore the uses of technology for space communications have shown that there will be many areas of application for public benefit. We expect that the Soviet COSPAS will be launched in mid-1982 and available to perform some portions of the Search and Rescue experiments.

Applied Research and Data Analysis

The proof-of-concept and base research technologies currently under development will be continued. More specifically, work will be continued on frequency reuse antennas; baseband regeneration processors; high-speed, high-bandwidth crossbar switches; digital and microwave integrated circuit technology, intersatellite link technology and component and device technology applicable to several frequency bands including both 14/12 and 30/20 GHz. Efforts will be made to insure that technology developed in the NASA program is coordinated with and supportive of DOD programs. In addition to these broadband spectrum and orbit conserving technologies, work will be undertaken on very high data rate technologies associated with future shuttle payloads and Low-Earth Orbital and Geosynchronous Earth Orbital platforms and on lower data rate technologies for public service, disaster/emergency and law enforcement applications.

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Search and Rescue Mission

The Search and Rescue Mission is being conducted as a multilateral demonstration program by Canada, France and the United States, using special instrumentation packages on board the U.S. NOAA series of meteorological spacecraft. The program will demonstrate improvements in the ability to detect, and then precisely locate, emergency signals transmitted from aircraft and ships in distress. The Soviet Union is collaborating in the program and plans to launch at least two COSPAS satellites compatible with the Canadian, French, and U.S. SARSAT system. In addition, to these major participants, Norway, Japan and the United Kingdom are expected to participate in the program as investigators by deploying test transmitters and ground stations compatible with the satellite.

All elements of the system are expected to be ready for the launch of the first two satellites in the series -- NOAA-E and COSPAS 1 -- by mid-1982.

The $3.7 million requested in FY 1983 will permit an analysis of the overall effectiveness of the system including its location accuracy and its overall impact in improving search and rescue operations. In addition, the FY 1983 funds will be used to complete the integration and test of the search and rescue instruments on the NOAA-F and G spacecraft and to make provision to accommodate Search and Rescue instruments on NOAA spacecraft H-J.

Technical Consultation and Support Studies

Major emphasis during FY 1983 will include continued activities leading towards the development of U.S. strategies, positions, and technologies needed to support U.S. positions at the three International Telecommunications Union (ITU) Regional and World Administrative Radio conferences scheduled for the 1983-1987 time frame. Decisions reached at these conferences will directly affect our country's access to the geostationary orbit and radio spectrum.

Experiment Coordination and Mission Support

This element of the Communications Program provides continued support of the Applications Technology Satellites, (ATS-1, -3, and -5), and the appropriate documentation and archiving of the wide range of user experiments and demonstrations in the application of satellite communications. Nearly 400 communications experiments using the ATS series and the Communications Technology Satellite (CTS) have been conducted successfully, both nationally and internationally, during the extended lifetimes of these satellites. The FY 1983 budget request of $1.0 million will cover continued ATS-1, -3, and -5 operations through September 1983.

SUPPORTING PROGRAMS

Our Suborbital and our Research and Analysis programs provide the foundation for our total scientific program. Research and Analysis activities fall into five general areas: extended data analysis, laboratory investigations, complementary ground-based observations, theoretical studies and instrument definition and development. Past missions have accumulated a wealth of data on a wide range of natural phenomena. In general, the data analysis during the operational lifetime of a mission cannot fully extract all the knowledge to be gained from the data. Extended data analysis continues to capitalize on the valuable data sets after missions are complete. Ground-based observations provide the complementary and ground-truth data needed to fully interpret the space observations. Laboratory investigations provide additional information on the physical process being observed, and theoretical studies provide a broad perspective on the observed phenomena. Our future missions build on the bases provided by past missions and supporting programs. Theoretical studies lead to new theories that must be tested and suggest new observations to test old theories. Instrument definition and development, which provides the technological base for our research missions, is a multifaceted activity which is carried out in the laboratory, on suborbital flights and on the Shuttle. In addition, as has been mentioned earlier, our life sciences program maintains a vigorous program of medical studies to understand the problems related to the health and well being of humans in space. These supporting programs provide a significant measure of the basic research support to the university, government and industrial scientific researchers who make up the heart of the space science and applications program.

Our suborbital program has seen considerable recent activity, with numerous sounding rocket, balloon and aircraft flights. FY 1981 saw the first flight of the Black Brant X rocket from Wallops Island, Virginia. This high performance, three stage vehicle was developed as a joint effort among United States, Canadian, and Swedish research institutions and is capable of high altitudes, extended distances, and high accuracy.

Over recent years, NASA has become the major user of balloons for scientific research. During this time, the National Science Foundation has been supporting the balloon operations program through its National Scientific Balloon Facility (NSBF) in Palestine, Texas. Discussions on a potential transfer of responsibility are continuing and we are considering the possibility of NASA taking responsibility for the operation of the NSBF sometime in FY 1983.

To enhance the science return from its space activities, NASA maintains an active scientific research aircraft program. Flights of U-2's and the ER-2 aircraft will continue from the Ames Research Center in support of the Airborne Instrument Research Program which concentrates on remote sensing of the Earth and its atmosphere. The Kuiper Airborne Observatory, a C-141 supporting the infrared astronomy program, will fly approximately 65 times during the coming year.

Each area of the Research and Analysis program has had significant accomplishments in the previous year, and continuing activity is planned for FY 1983. In extended data analysis, for instance, efforts will continue on the Viking Lander data although at a somewhat slower pace than previously planned. Data collected and analyzed through three Martian autumn-winter-spring cycles show variations of pressure and illumination at the landing site which lead to the conclusion that local dust storms during the winter months produced movement of the dust which modulates the seasonal CO_2 cycle.

In the area of laboratory investigations, a broad based research effort continues in life sciences, searching for mechanisms underlying the cardiovascular changes observed in simulated spaceflight. Laboratory studies of cometary phenomena are being conducted to prepare for the ground and spacecraft observations of Comet Halley in 1986. Measurements also are being made of the rates of chemical reactions involving stratospheric constituents for use in predictive models of the upper atmosphere chemistry and in the design of new measurement techniques.

In the ground-based/collateral data study area, efforts continue in planetary astronomy, where recent results include studies of Jupiter's ring and of volcanoes on its satellite Io. The ring around Jupiter discovered by Voyager I has now been observed directly from the Earth. It also has been determined that, unlike the icy rings of Saturn, Jupiter's ring consists of rocky material. The volcanoes on Io, also discovered by Voyager, can now be monitored with Earth-based telescopes. Such follow-up studies of planetary spacecraft results will be continued.

In technique testing, joint tests are conducted with major resource and commodity decision-makers in representative applications. Technique tests of irrigated lands for assessment of water management and monitoring of insect defoliation of hardwood forests will be completed in FY 1982, while utilization of soils data in crop classification and mapping of irrigated croplands in western aquifers is continuing. Several new technique tests will be pursued in FY 1982 and FY 1983 with emphasis on testing Thematic Mapper Simulator techniques for use in hydrology, coastal wetlands, forestry, facility siting, and agribusiness. These tests will help determine the utility of remote sensing techniques in real world applications and serve to guide our future research and development program.

The tropospheric air quality program has carried out ground-based measurements of the atmospheric concentration of methane, indicating an increase that may have climate implications. These data are just one part of the study of tropospheric air chemistry.

In the theoretical study area, several activities are continuing. The Solar Terrestrial Theory Program is a cohesive effort by groups of theoreticians and computational physicists to study the processes that are important to solar terrestrial relations. A number of significant developments have been achieved including a new contribution to the theory of heat flow in the Earth's polar wind and its effect on ionosphere-magnetosphere energy exchange. Chemical modeling is an important component of the planetary atmospheres program, and the Voyager discovery of hydrogen cyanide molecules on Titan has further stimulated efforts. Hydrogen cyanide is a key compound in the synthesis of amino acids, believed to be the forerunner of living organisms. It had previously been observed in interstellar space but not in planetary atmospheres. Studies of Titan's complex hydrocarbon chemistry are being undertaken to identify the formation processes for the molecules believed to be responsible for Titan's haze layer.

Instrument development continues in many areas. In astrophysics, for instance, we are working on X-ray mirror technology with the aim of increasing spatial resolution and collecting area. These mirrors will have wide application in astronomy and solar physics. Effort is also underway directed toward developing new detectors for X-ray, cosmic-ray and gamma-ray astronomy.

In data processing technologies, the Information Systems Office supports a wide variety of multi-disciplinary OSSA programs. The objective of the Information Systems Program is to evolve data system capabilities by applying a broad range of computer technologies to research projects and flight missions, resulting in improved access to and utilization of higher quality data. Space science and earth applications missions such as Spacelab, Landsat, and Space Telescope will be generating increasing volumes of data at greater rates, with increased pressures from users for more efficient and cost effective yet sophisticated processing capabilities. The FY 1983 program will begin to provide the foundation for the timely development of information systems capabilities and concepts to meet initial needs of future programs, thereby reducing ground data system development risks.

These brief examples are intended to show the scope of the supporting program, and demonstrate how the activities provide essential support for past, present and future missions. The number of individual tasks is much too large to do more than scratch the surface of the activity; it would be impossible to review the whole program fairly here. However, each task, like a piece in a jigsaw puzzle, plays an essential role in the effort to carry out our space science and applications program.

FUTURE PROGRAMS

So far, I have described to you programs and activities that are currently underway. The Office of Space Science and Applications also has a planning activity which looks toward future opportunities to build upon previous results or to initiate new lines of research. I would like to conclude my statement by indicating a few of the possibilities. (Fig. 33 and 34)

With the launch of the first orbiting X-ray telescopes, it became clear that we knew very little about the many violent, explosive regions in the universe. The results of HEAO-2 have shown the value of yet higher resolution imaging X-ray telescopes to investigate the nature and evolution of the forces that make stars, galaxies and quasars. During the past several years we have been defining the Advanced X-Ray Astrophysics Facility (AXAF) as a potential candidate future mission which is a free flying X-ray observatory that will be Shuttle-launched, serviceable in orbit, and retrievable. Our studies show that AXAF can be made 100 times more sensitive than HEAO-2. Current work is concentrating on the development of the X-ray mirror technology which is at the heart of this mission.

The objective of the Gravity Probe B (GP-B) mission is to place extremely precise gyroscopes into a polar orbit to see if the spin of the earth can change the direction the gyros point. According to general relativity, the rotation of the Earth literally drags space around with it producing a small extra motion of gyroscopes which is not predicted by Newtonian physics. In the last 20 years we have succeeded in developing the technology capable of sensing this effect, which will provide a fundamentally new test of Einstein's General Theory of Relativity. GP-B has started definition efforts for the systems and subsystems of the spacecraft and instrument. In FY 1982 and 1983, the definition studies will be completed, and a final breadboard demonstration of high technology items will be accomplished. At the end of these activities, the mission will be considered for a new start.

The Extreme Ultraviolet Explorer (EUVE) will survey the sky in a part of the electromagnetic spectrum that heretofore has remained relatively unexplored. Although we knew from theory that stars should radiate copiously in the extreme ultraviolet, it was not until the Apollo-Soyuz mission that we discovered that the interstellar medium around the Sun was dilute enough to let us see several hundred light years around the Sun. In FY 1983, mission definition and design will be continued.

In addition to major observatories like AXAF, more specialized missions designed to study specific problems with specialized instruments are needed in X-ray astronomy. The X-Ray Timing Explorer (XTE) is planned to carry out extensive studies of the temporal variations in X-ray sources over a broad energy range. Such observations will provide essential new data on the internal constitution of white dwarf and neutron stars, on the physical processes occurring in the vicinity of black holes, and on the swirling disks of hot gas which surround these objects. FY 1983 funds will be used to initiate early definition studies of the spacecraft and instrument complement.

The Shuttle Infrared Telescope Facility (SIRTF) is being planned to study the cool regions of space, such as dust and gas clouds where stars are forming, and the planets, asteroids and comets of our solar system. It will be at least a thousand times more sensitive than any ground-based telescope, and a hundred times more sensitive than other space systems. SIRTF's unique capabilities will be key to major advances in diverse fields of astronomy. Initiation of a Phase B study is being considered for FY 1983.

Obtaining an understanding of our twin sister planet, Venus, continues to be essential to obtaining an understanding of Earth itself as well as being necessary for understanding the history of the inner solar system. In particular there remains a need for studying the geology of the surface of Venus. The agency is continuing to look at options for a Venus mapping mission as an important part of its future program planning.

An ongoing study is underway to provide a long-term mission strategy for the exploration of the entire solar system, including the inner planets, outer planets, and small bodies. The small bodies are relatively primitive objects. Therefore, they offer exceptional promise in helping us understand the original state of the solar system; accordingly, the small bodies will be given high priority in our mission planning. By the fall of this year, we expect this study to be finished thereby providing a long-term, balanced mission strategy and an affordable implementation approach. As a result, we can anticipate that we will again be in a position to make significant progress across a broad front, toward our ambitious goal of understanding the origin and evolution of the solar system and our own planet.

Turning closer to home, the next major step in the study of the Earth's magnetosphere is a study of the global flow of energy and matter in the Earth's space environment, its energization and it storage. In order to do this, we are planning the Origin of Plasmas in Earth's Neighborhood (OPEN) program as a candidate new thrust in our study of Sun-Earth relationships. In its current concept OPEN consists of four spacecraft making closely coordinated measurements of the major regions of the Earth's environment where energy is known to be stored or transported: the solar wind, the magnetosphere, the ionosphere and the tail of the Earth's magnetic field. We have recently selected a set of investigations for definition and will be undertaking definition studies of both instruments and spacecraft during the next year.

We also are planning to use Shuttle/Spacelab to carry out a new generation of "active" experiments in space plasma physics. Controlled experiments to examine the reaction of the Earth's magnetosphere to the introduction of energetic particles will be conducted using particle beam accelerators and electromagnetic wave injection mechanisms.

As has been discussed earlier, a fundamental problem in oceanography is the determination of the direction and speed of the water flow of the Ocean Circulation. The Global Ocean Topography Experiment (TOPEX) is planned to use a spacecraft-borne radar altimeter to measure the height of the sea surface, from which the global circulation of the oceans can be determined for the first time. The TOPEX Science Working group has determined the scientific requirements of such a mission and published its findings in 1981. A conceptual design study for such a space mission has also been completed and indicates that the idea is feasible. Future activities will involve a study of options for a candidate TOPEX mission.

We also continue to study new techniques to investigate surface geology and to gain new insights on the Earth's interior. The Shuttle Active Microwave Experiment (SAMEX), is planned to be a major evolutionary advancement in Synthetic Aperture Radar instrumentation. Among the scientific objectives of SAMEX is obtaining a better understanding of the imaging radar signature of different lithologic units, structural features, and surface covers. The experience gained from SAMEX imagery of the Earth will be of considerable value in planning future planetary radar imaging missions.

The GRAVSAT/MAGSAT mission is being planned to make more quantitative interpretations of the Earth's gravity field to advance our understanding of the theory of global plate tectonics and to continue studies of the decay and secular variation of the Earth's magnetic field. In its current concept, the mission consists of two spacecraft which follow one another in orbit at an altitude of 160 km. Variations in the Earth's gravity field will be studied by the results of satellite-to-satellite ranging. The mission concept has been developed over the past two years, and the conceptual feasibility of critical elements has been demonstrated through computer simulations and laboratory tests.

The Multispectral Linear Array (MLA) activity is a development effort leading to an advanced, high performance sensor applicable to advanced missions for fundamental research in remote sensing. The emphasis in the current program is on developing an all solid state MLA sensor incorporating a new generation of detector materials, visible and shortwave infrared (SWIR) multispectral linear focal plane arrays, on-board signal processing and ground data processing concepts. The FY 1983 MLA activities will continue the technology development, instrument definition and long term development of an innovative and versatile imaging spectrometer sensor.

In addition to individual missions, we have been studying for some time new approaches to carrying out investigations in space. For example, a space platform might be a logical first step toward achieving a permanent presence in space. Such a platform could be a Shuttle-tended spacecraft with on-orbit replaceable propulsion and subsystem modules, which would provide utilities, stabilization and accessibility for a wide variety of temporarily emplaced payloads. Many of the payloads on an early space platform mission could be derived from those developed for the Spacelab payload program as a logical extension for those investigations requiring longer duration flights. As a space platform utilization program matures, payloads designed specifically to exploit its capability could be developed.

Finally, as indicated at the beginning of my statement, the combination of the Science and Applications program has given us a new opportunity to study the Earth from a planetary perspective and, in particular, to study the influence of life itself on the planet. For the first time, we are now able to monitor, on a global scale, the interaction of the Earth's biota with all elements of the biosphere-the land, oceans and atmosphere. Such studies should provide answers to fundamental questions about how biology modulates the cycling of key elements and molecules between these components, and thereby allow better understanding of the stability of the ecosystem as a whole, as well as predictions regarding the short and long term effects of perturbations, both natural and life-related. Our ultimate objective would be to understand life on Earth as a planetary phenomenon, a phenomenon whose origin, evolution and current state is inseparable from the origin, evolution and current state of the planet itself.

As is evident, there are many exciting possibilities for major future advances in our understanding of the universe, the solar system, the Sun and the Sun-Earth connection and the Earth itself. As I indicated at the beginning of my statement, NASA has accomplished much over the last two decades. I hope to play a significant part in setting the course towards the productive future that lies ahead for the rest of the century.

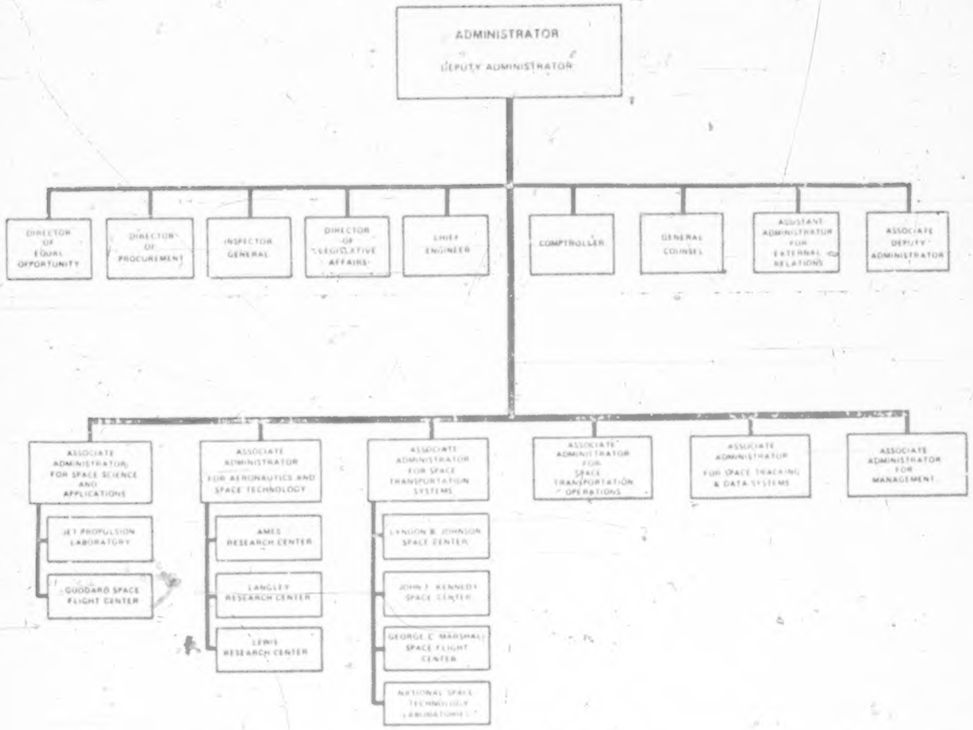

ADMINISTRATOR
DEPUTY ADMINISTRATOR
DIRECTOR OF EQUAL OPPORTUNITY
DIRECTOR OF PROCUREMENT
INSPECTOR GENERAL
DIRECTOR OF LEGISLATIVE AFFAIRS
CHIEF ENGINEER
COMPTROLLER
GENERAL COUNSEL
ASSISTANT ADMINISTRATOR FOR EXTERNAL RELATIONS
ASSOCIATE DEPUTY ADMINISTRATOR
ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS
JET PROPULSION LABORATORY
GODDARD SPACE FLIGHT CENTER
ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
AMES RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION SYSTEMS
LYNDON B. JOHNSON SPACE CENTER
JOHN F. KENNEDY SPACE CENTER
GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL SPACE TECHNOLOGY LABORATORIES
ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION OPERATIONS
ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING & DATA SYSTEMS
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

FIG. 1

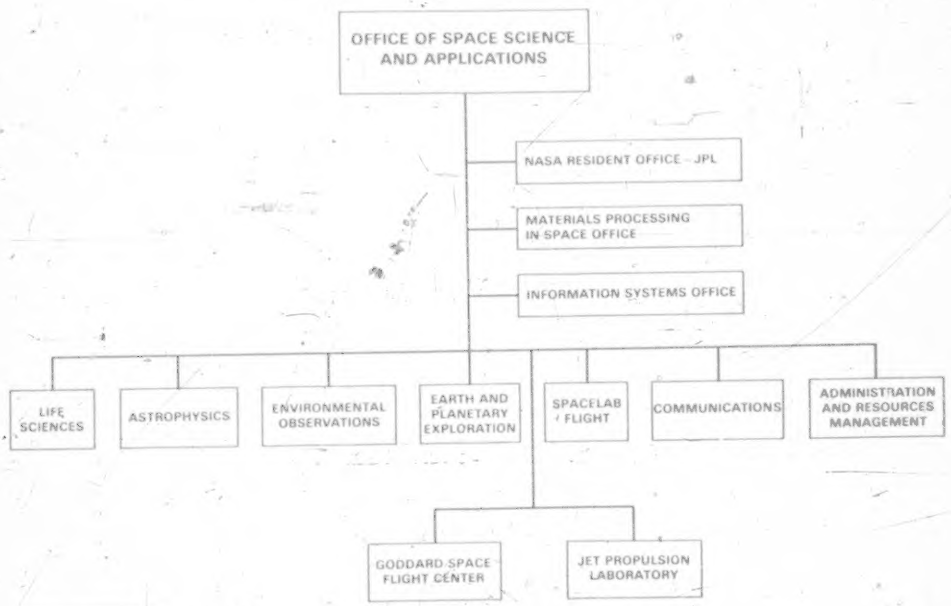

OFFICE OF SPACE SCIENCE AND APPLICATIONS
NASA RESIDENT OFFICE - JPL
MATERIALS PROCESSING IN SPACE OFFICE
INFORMATION SYSTEMS OFFICE
LIFE SCIENCES
ASTROPHYSICS
ENVIRONMENTAL OBSERVATIONS
EARTH AND PLANETARY EXPLORATION
SPACELAB FLIGHT
COMMUNICATIONS
ADMINISTRATION AND RESOURCES MANAGEMENT
GODDARD SPACE FLIGHT CENTER
JET PROPULSION LABORATORY

FIG. 2

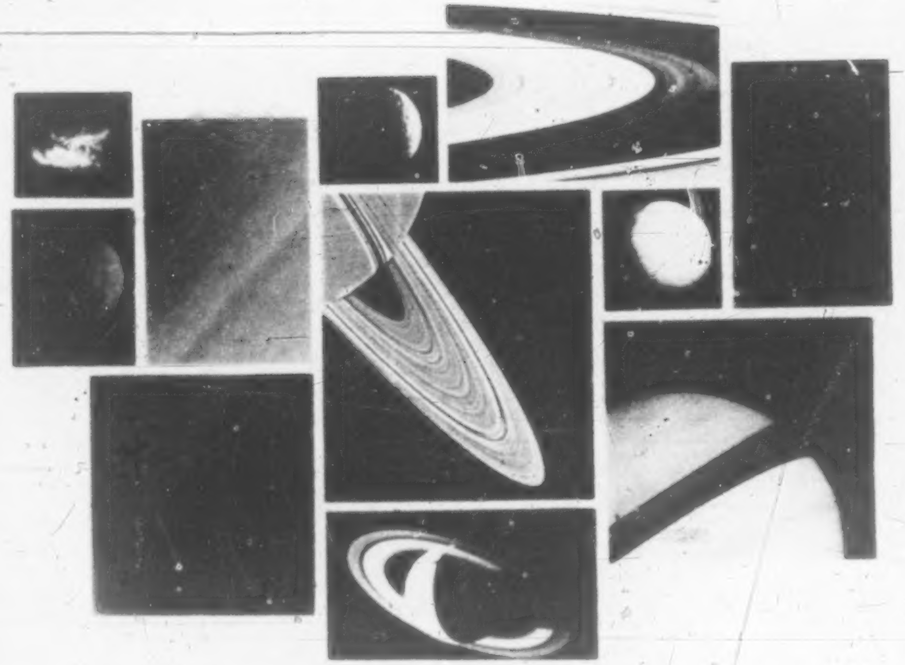


FIG. 3.

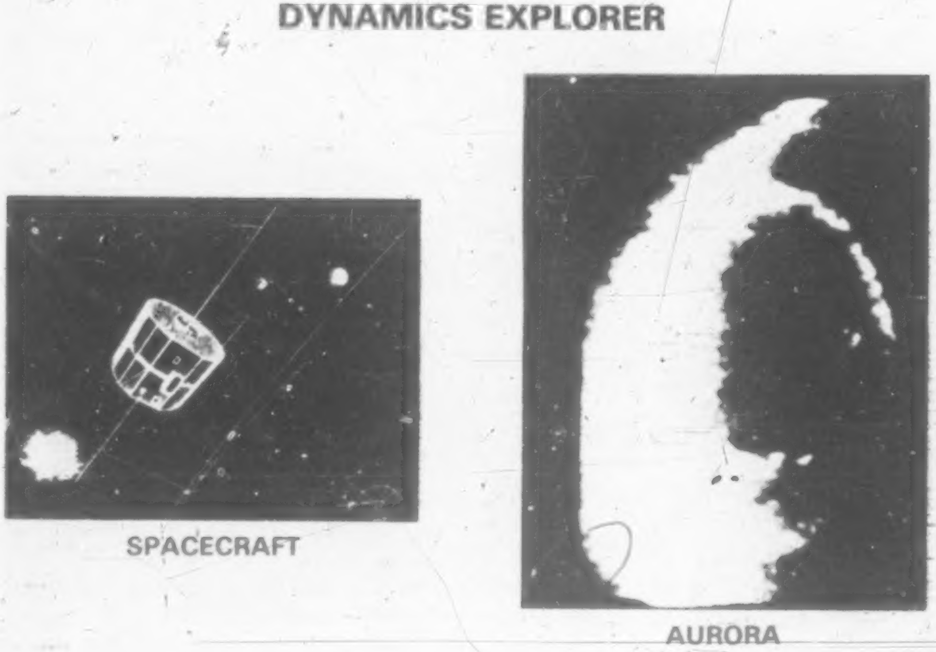
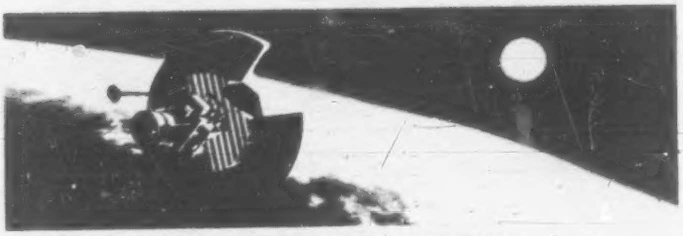
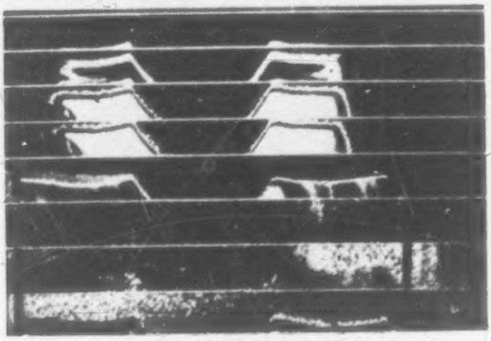

DYNAMICS EXPLORER
SPACECRAFT
AURORA

FIG. 4

SOLAR MESOSPHERE EXPLORER



SME SPACECRAFT & SUN

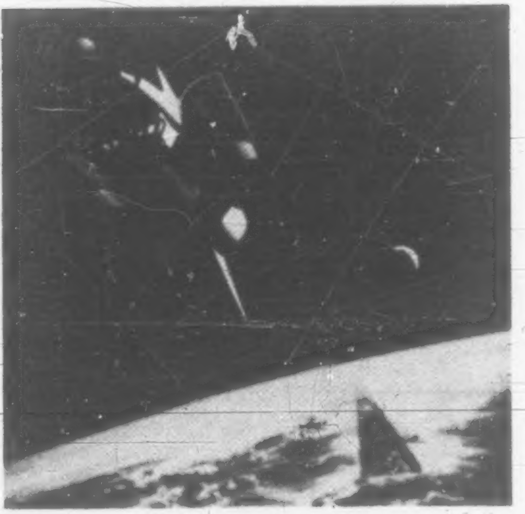


OZONE PROFILE

FIG. 5

OSTA-1 RESULTS

SHUTTLE IMAGING RADAR-A (SIR-A)



PERFORMANCE:

- 10 MILLION SQUARE KILOMETERS COVERAGE
- WIDE VARIETY OF GEOLOGIC FEATURES IMAGED
- RESOLUTION 36-40 METERS

FIG. 6

SIR-A IMAGE
OIL RIGS AND VESSELS (PERSIAN GULF)

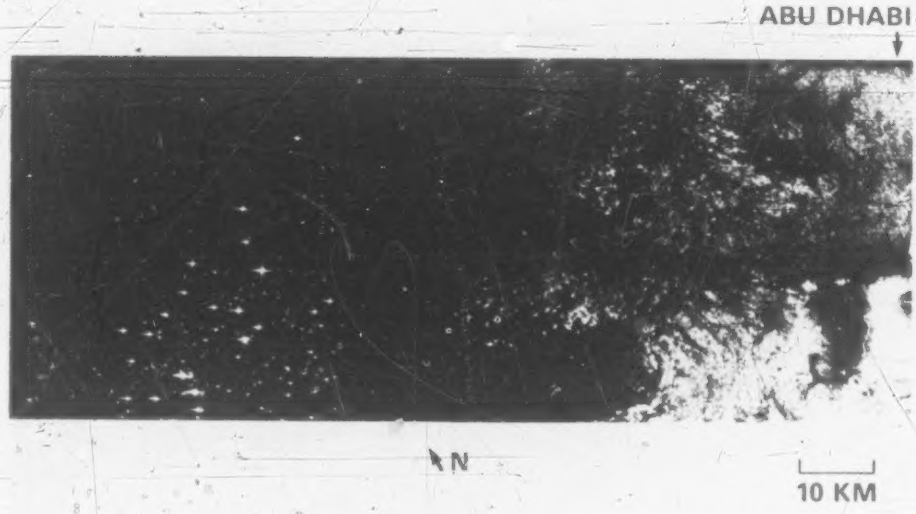
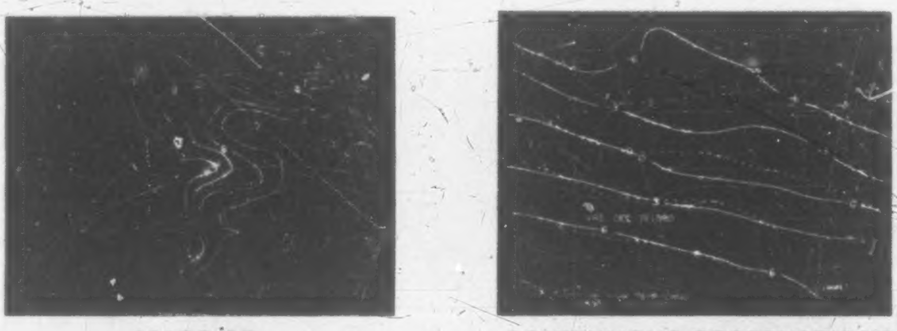


FIG. 7

VISIBLE AND INFRARED SPIN SCAN RADIOMETER ATMOSPHERIC SOUNDER (VAS)



MAPS OF
RELATIVE HUMIDITY

CONTINUOUS OBSERVATIONS
3-HOUR TEMPERATURE CHANGES
AT 1.4 km ALTITUDE

FIG. 8

OFFICE OF SPACE SCIENCE AND APPLICATIONS FY 1983 BUDGET REQUEST

(DOLLARS IN MILLIONS)

	FY 1982		FY 1983
	MARCH AMENDMENT	OPERATING PLAN	REQUEST
SPACE APPLICATIONS TOTAL	372.9	325.8	316.3
RESOURCE OBSERVATIONS			
LANDSAT-D	83.9	83.9	61.7
EXTENDED MISSION OPERATIONS	2.8	2.8	1.8
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT	2.0	3.3	2.8
GEODYNAMICS	30.9	22.9	26.2
AgRISTARS	23.1	14.0	15.0
APPLIED RESEARCH AND DATA ANALYSIS	22.7	19.5	24.7
SUBTOTAL	165.4	146.4	132.2
ENVIRONMENTAL OBSERVATIONS			
UPPER ATMOSPHERIC REACH PROGRAM	15.0	13.0	16.5
APPLIED RESEARCH AND DATA ANALYSIS	56.5	47.0	54.7
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT	4.1	4.1	3.7
OPERATIONAL SATELLITE IMPROVEMENT PROGRAM	11.8	6.0	6.0
EARTH RADIATION BUDGET EXPERIMENT	24.0	24.0	24.0
EXTENDED MISSION OPERATION	11.4	11.4	10.0
UPPER ATMOSPHERIC RESEARCH SATELLITE EXPERIMENT AND MISSION DEFINITION	5.0	6.0	14.0
HALOGEN OCCULTATION EXPERIMENT	7.5	5.0	—
SUBTOTAL	135.3	116.5	128.9
APPLICATIONS SYSTEMS	14.2	13.2	11.7
TECHNOLOGY TRANSFER			
USER REQUIREMENTS AND SUPPORT ACTIVITIES	—	3.0	—
REGIONAL REMOTE SENSING PROGRAM	—	2.0	—
SUBTOTAL	—	5.0	—
MATERIALS PROCESSING IN SPACE			
APPLIED RESEARCH AND DATA ANALYSIS	14.0	12.0	13.1
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT	7.6	8.8	3.3
MATERIAL EXPERIMENT OPERATIONS	6.1	3.0	7.2
SUBTOTAL	27.1	23.8	23.6

FIG 9

OFFICE OF SPACE SCIENCE AND APPLICATIONS FY 1983 BUDGET REQUEST (CONTINUED)

(DOLLARS IN MILLIONS)

	FY 1982		FY 1983
	MARCH AMENDMENT	OPERATING PLAN	REQUEST
COMMUNICATIONS AND INFORMATION SYSTEMS			
APPLIED RESEARCH AND DATA ANALYSIS	15.4	10.0	5.1
SEARCH AND RESCUE	1.3	2.3	3.7
TECHNICAL CONSULTATION AND SUPPORT	2.6	2.6	2.6
EXPERIMENT COORDINATION AND OPER. SUPPORT	1.0	1.0	1.0
INFORMATION SYSTEMS	10.0	5.0	7.5
SUBTOTAL	30.3	20.9	19.9
PHYSICS AND ASTRONOMY — TOTAL	325.4	323.5	471.7
SPACE TELESCOPE DEVELOPMENT	119.5	121.5	137.5
INTERNATIONAL SOLAR POLAR MISSION DEV.	5.0	5.0	21.0
GAMMA RAY OBSERVATORY DEVELOPMENT	8.0	8.0	34.5
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT	35.0	40.0	81.4
EXPLORER DEVELOPMENT	36.6	33.3	34.3
MISSION OPERATIONS AND DATA ANALYSIS	47.0	50.0	85.6
RESEARCH AND ANALYSIS	38.8	32.9	39.2
SUBORBITAL PROGRAMS	35.5	32.8	38.2
PLANETARY EXPLORATION — TOTAL	215.3	206.0	154.6
GALILEO DEVELOPMENT	108.0	120.0	92.6
VENUS ORBITING IMAGING RADAR	10.0	—	—
MISSION OPERATIONS AND DATA ANALYSIS	45.8	38.3	26.5
RESEARCH AND ANALYSIS	51.5	46.7	35.5
LIFE SCIENCES — TOTAL	43.5	39.5	55.7
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT	14.0	14.0	24.0
RESEARCH AND ANALYSIS	29.5	25.5	31.7
TOTAL OFFICE OF SPACE SCIENCE AND APPLICATIONS	957.1	893.8	998.3

FIG. 10

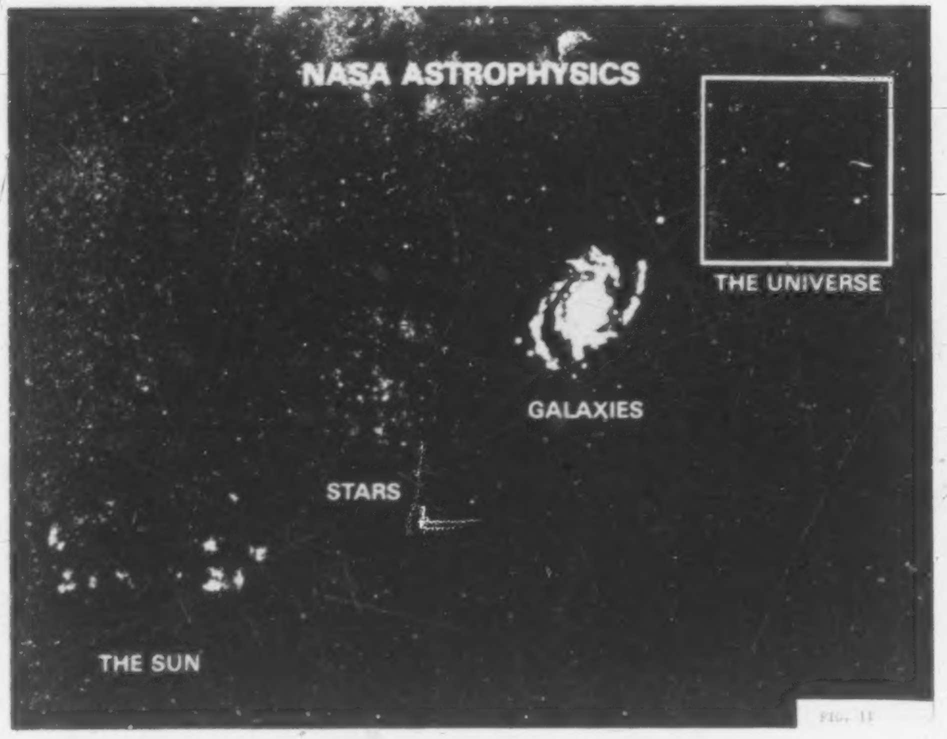

NASA ASTROPHYSICS
THE UNIVERSE
GALAXIES
STARS
THE SUN

FIG. 11

SPACE TELESCOPE

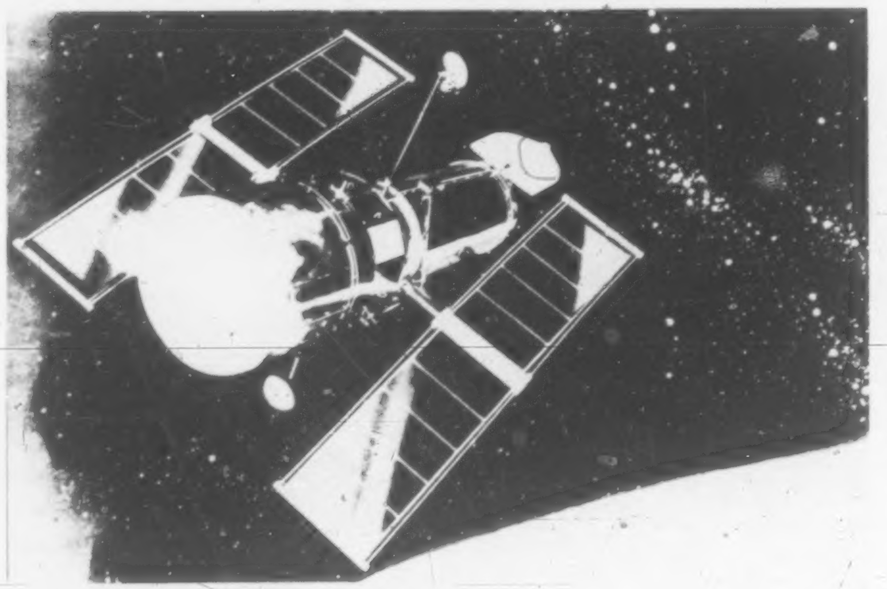


FIG. 12

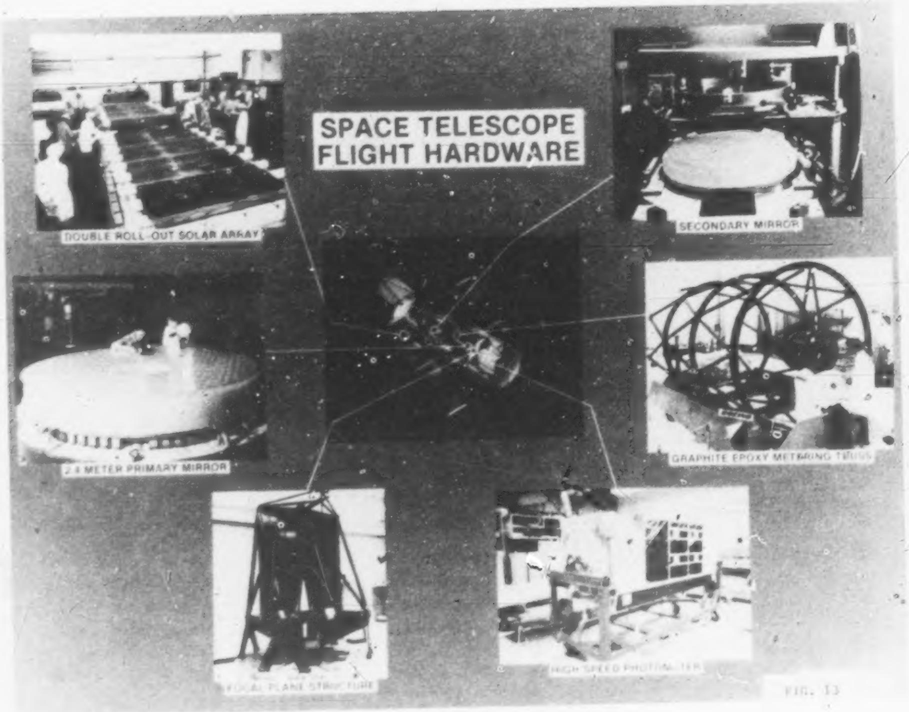

SPACE TELESCOPE
FLIGHT HARDWARE
DOUBLE ROLL-OUT SOLAR ARRAY
SECONDARY MIRROR
2.4 METER PRIMARY MIRROR
GRAPHITE EPOXY METERING TRUSS
FOCAL PLANE STRUCTURE
HIGH SPEED PHOTOMETER

FIG. 13

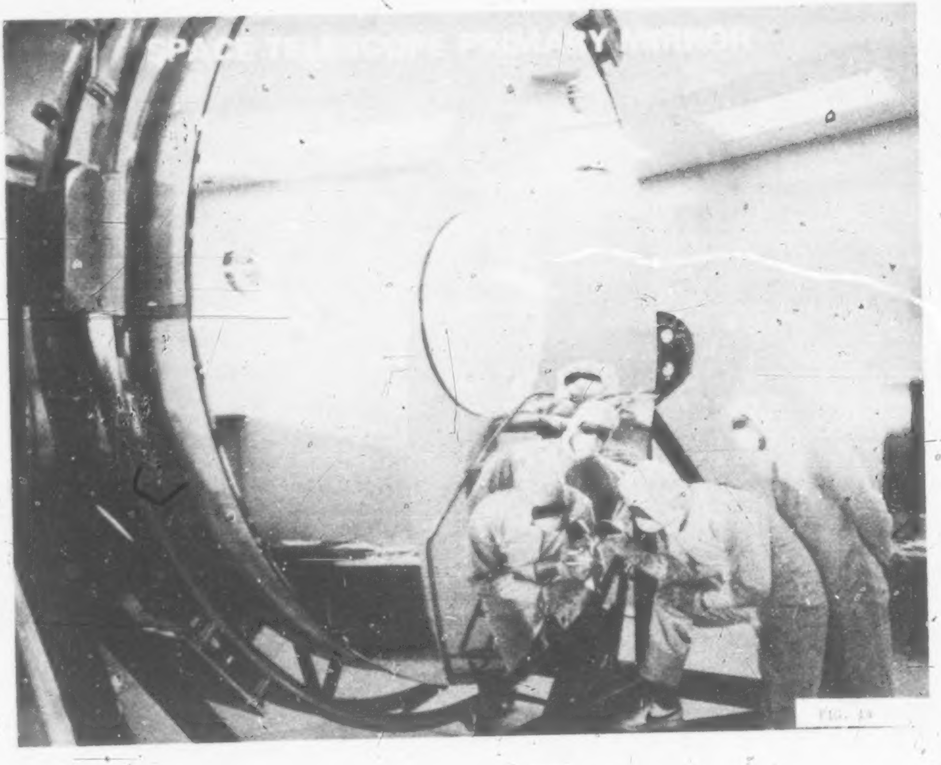
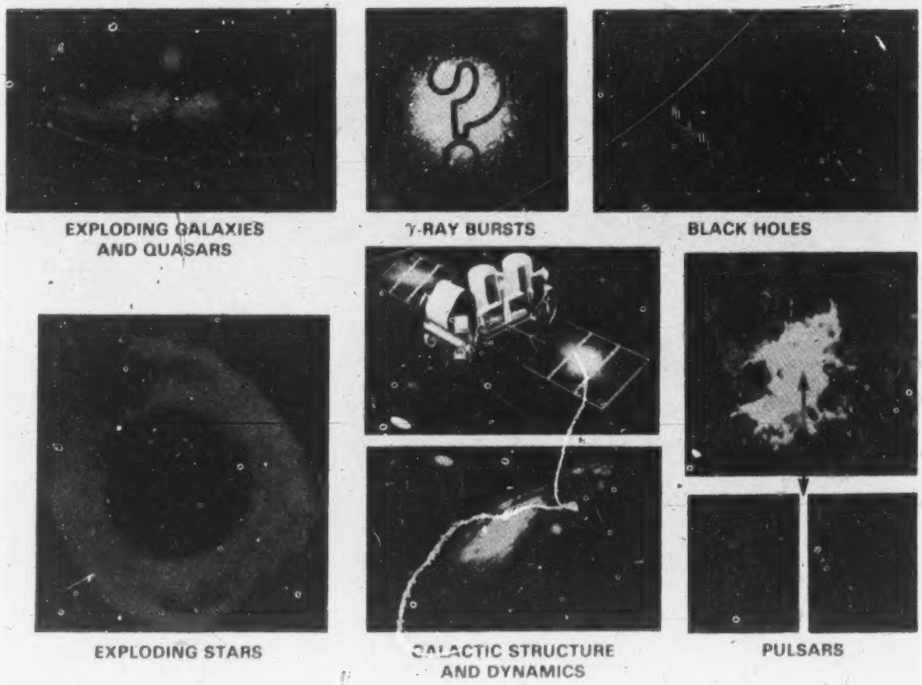

SPACE TELESCOPE PRIMARY MIRROR

FIG. 14

MAJOR QUESTIONS ADDRESSED BY GRO



EXPLODING GALAXIES AND QUASARS

γ-RAY BURSTS

BLACK HOLES

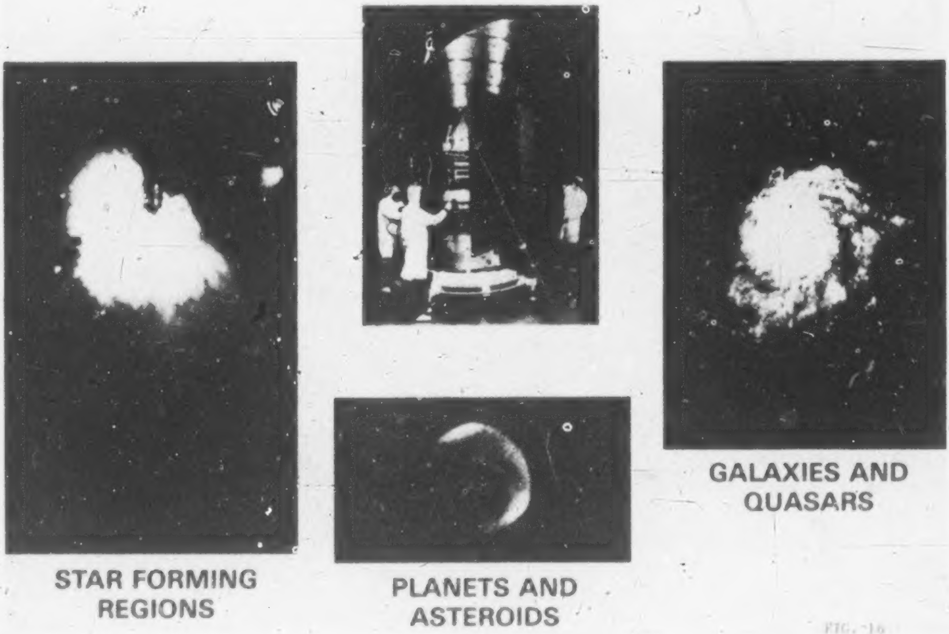
EXPLODING STARS

GALACTIC STRUCTURE AND DYNAMICS

PULSARS

FIG. 15

INFRARED ASTRONOMY SATELLITE



STAR FORMING REGIONS

PLANETS AND ASTEROIDS

GALAXIES AND QUASARS

FIG. 16

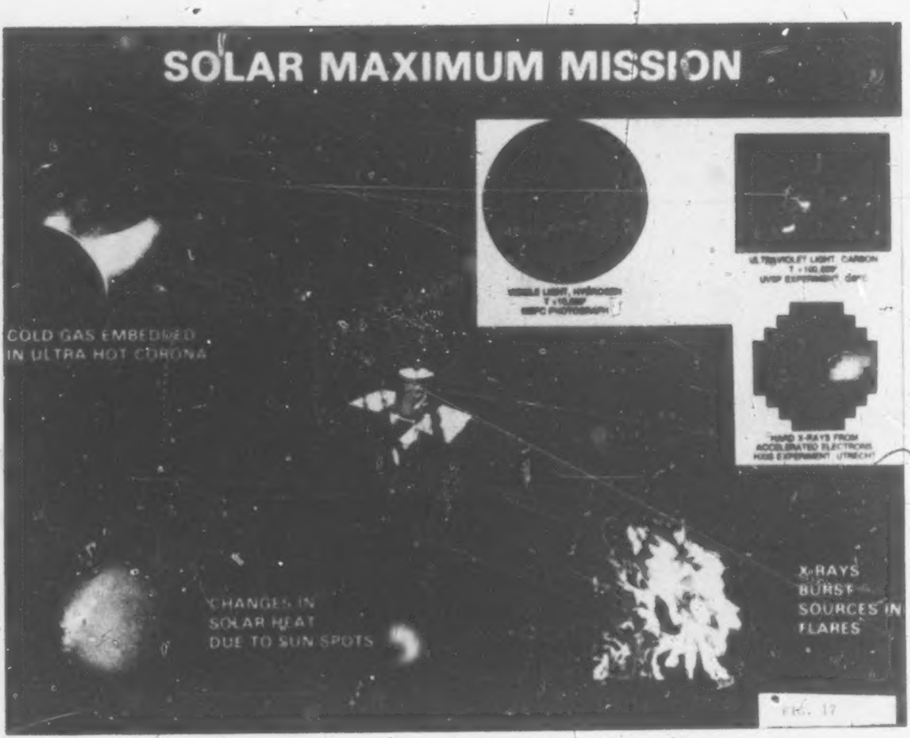

SOLAR MAXIMUM MISSION
VISIBLE LIGHT, HYDROGEN
T = 10,000°
PHOTOGRAPH
ULTRAVIOLET LIGHT CARBON
T = 100,000°
UVSP EXPERIMENT GSFC
HARD X-RAYS FROM
ACCELERATED ELECTRONS
HXIS EXPERIMENT UTRECHT
COLD GAS EMBEDDED
IN ULTRA HOT CORONA
CHANGES IN
SOLAR HEAT
DUE TO SUN SPOTS
X-RAYS
BURST
SOURCES IN
FLARES

FIG. 17

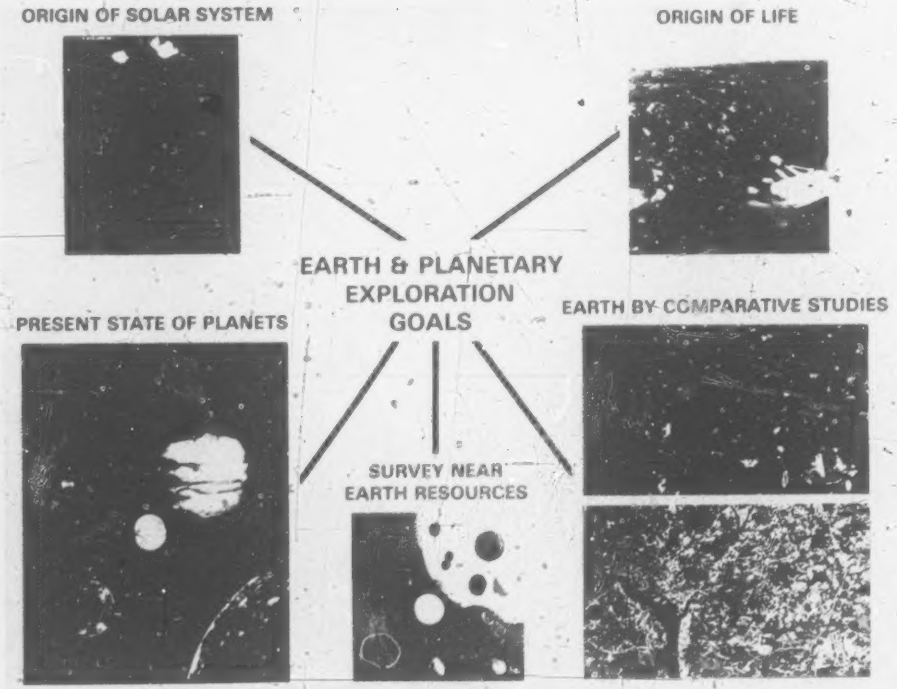
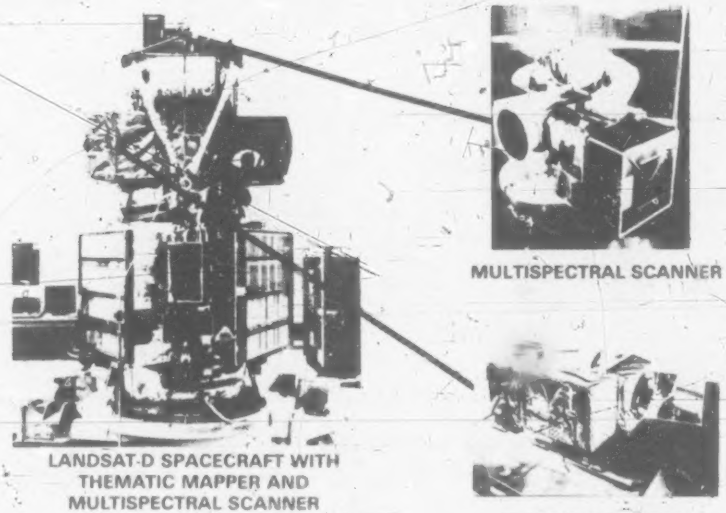

ORIGIN OF SOLAR SYSTEM
ORIGIN OF LIFE
EARTH & PLANETARY
EXPLORATION
GOALS
PRESENT STATE OF PLANETS
EARTH BY COMPARATIVE STUDIES
SURVEY NEAR
EARTH RESOURCES

FIG. 18

LANDSAT-D

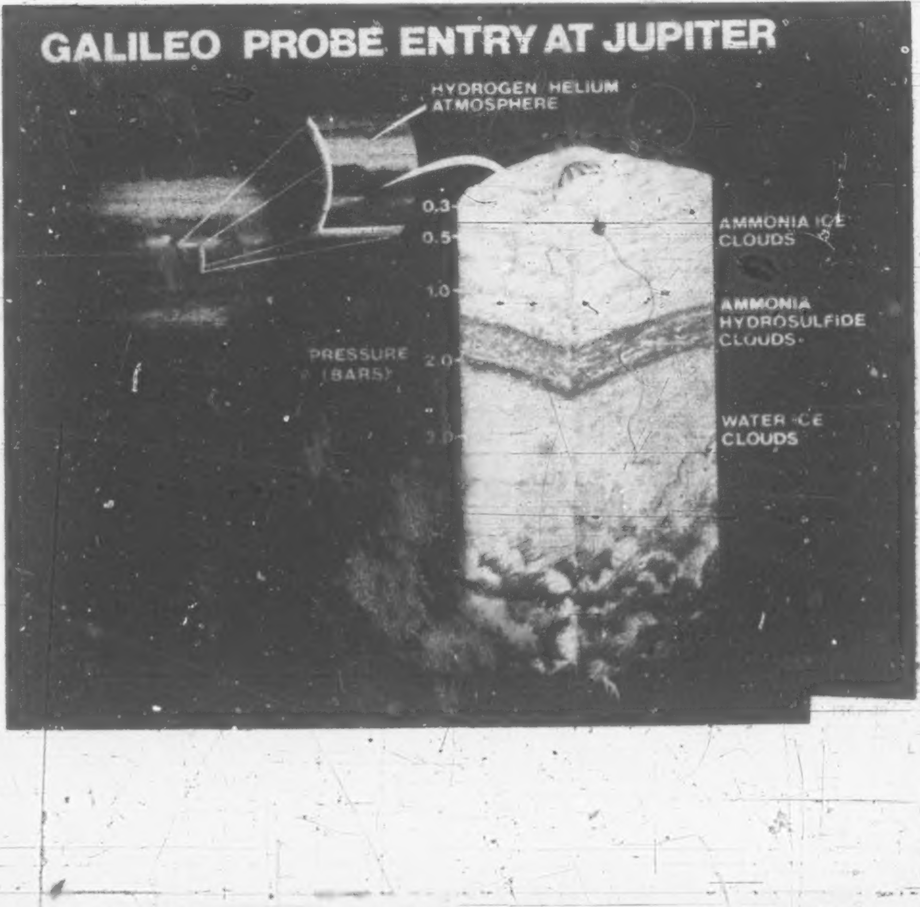


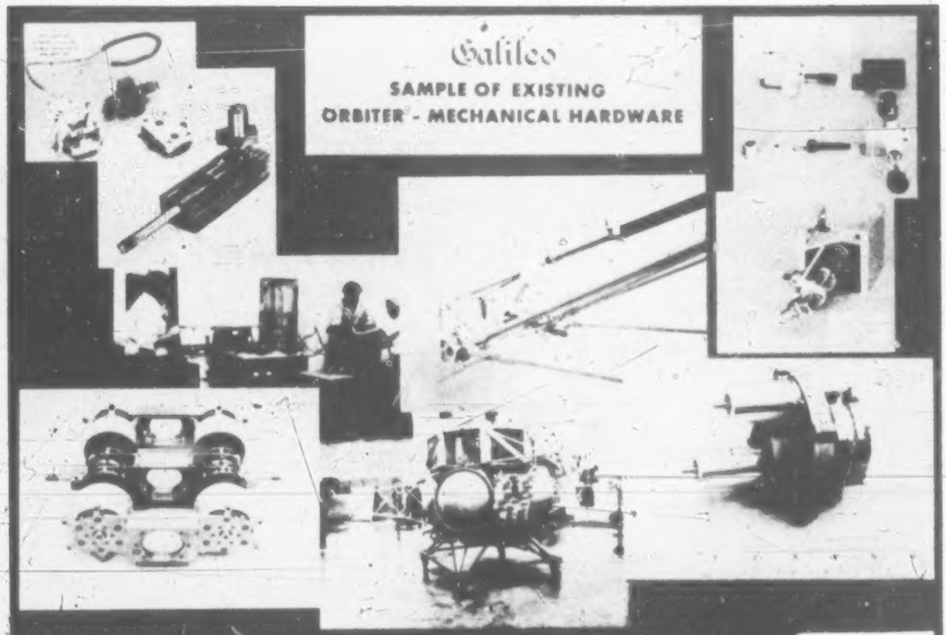
MULTISPECTRAL SCANNER

LANDSAT-D SPACECRAFT WITH THEMATIC MAPPER AND MULTISPECTRAL SCANNER INTEGRATED

THEMATIC MAPPER

FIG. 19


GALILEO PROBE ENTRY AT JUPITER
HYDROGEN HELIUM ATMOSPHERE
0.3
0.5
1.0
2.0
3.0
PRESSURE (BARS)
AMMONIA ICE CLOUDS
AMMONIA HYDROSULFIDE CLOUDS
WATER ICE CLOUDS



Galileo

SAMPLE OF EXISTING
ORBITER - MECHANICAL HARDWARE

FIG. 21

INTERNATIONAL SOLAR POLAR MISSION

COSMIC RAYS
SOLAR MAGNETIC FIELD
ISPM
SOLAR ENERGETIC PARTICLES
INTERSTELLAR GAS AND DUST
SOLAR ELECTROMAGNETIC RADIATION
EARTH ORBIT
SOLAR WIND

FIG. 22

COMET HALLEY STUDIES

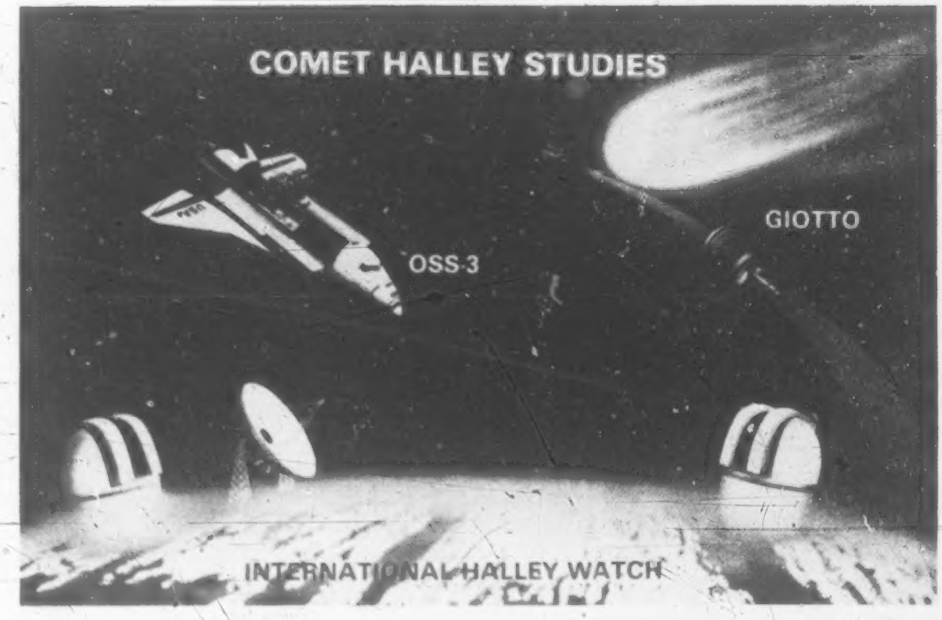
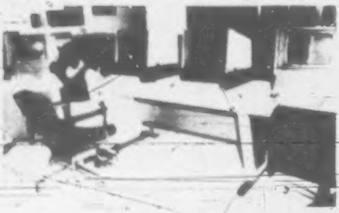

GIOTTO
OSS-3
INTERNATIONAL HALLEY WATCH

FIG. 23

ENVIRONMENTAL OBSERVATIONS

ADVANCE OUR KNOWLEDGE AND UNDERSTANDING OF THE ATMOSPHERE, OCEANS AND CLIMATE

OBSERVE



ANALYZE

FORECAST

FIG. 24

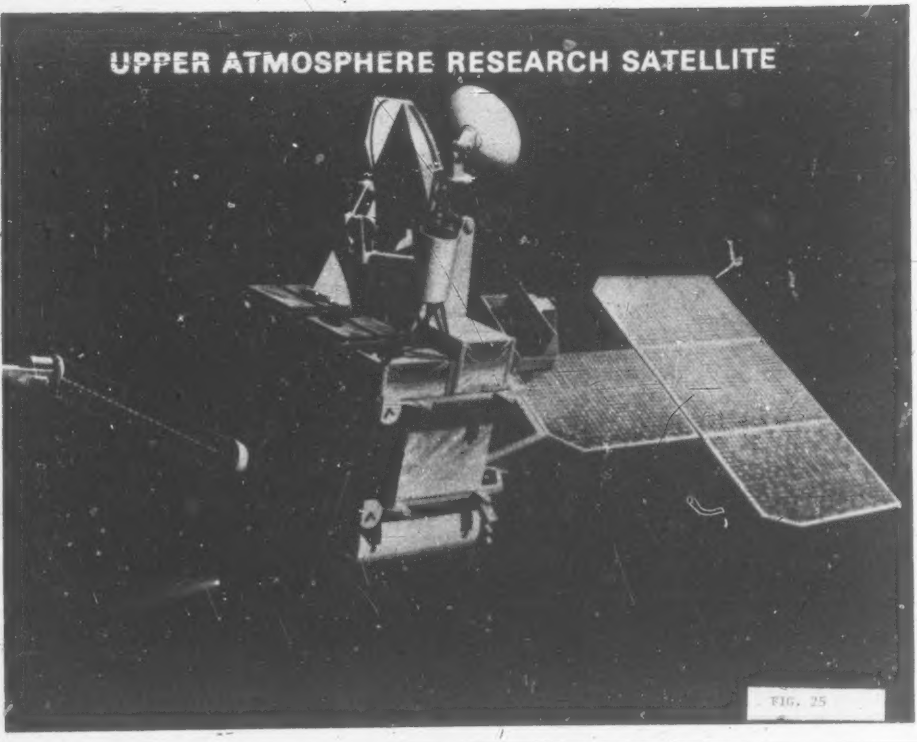

UPPER ATMOSPHERE RESEARCH SATELLITE

FIG. 25

EARTH RADIATION BUDGET EXPERIMENT (ERBE)

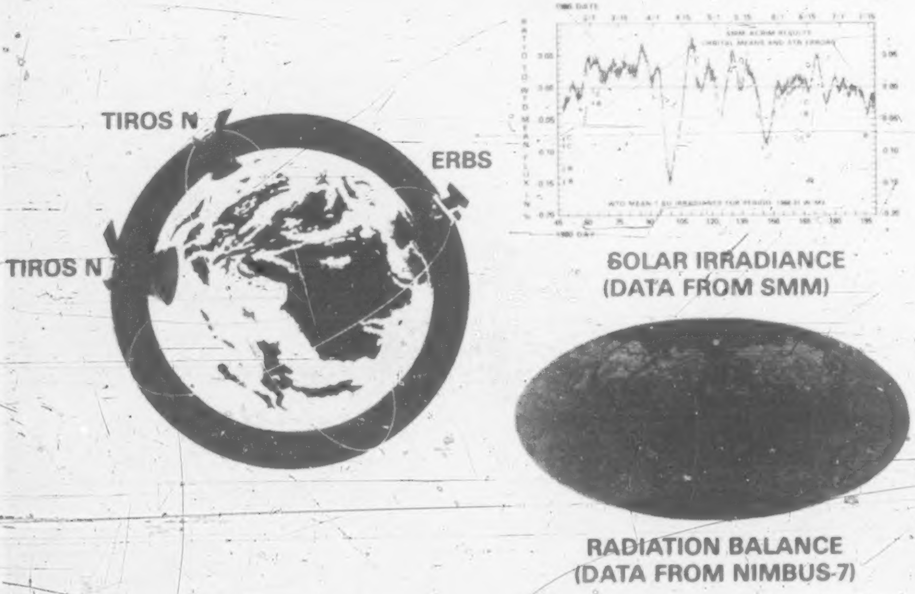
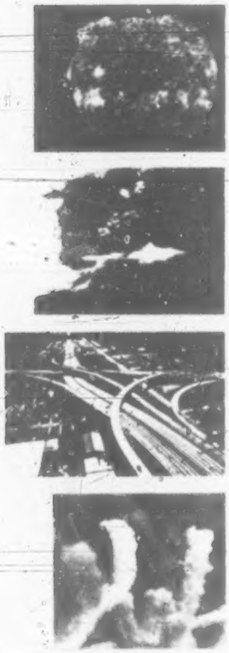

TIROS N
ERBS
TIROS N
1980 DATE
SMM ACRIM RESULTS
ORBITAL MEANS AND STN ERRORS
RATIO TO WTD MEAN FLUX IN %
0.05
0.10
0.15
0.20
45
60
75
90
105
120
135
150
165
180
195
1980 DAY
SOLAR IRRADIANCE
(DATA FROM SMM)
RADIATION BALANCE
(DATA FROM NIMBUS-7)

FIG. 26

CLIMATE LONG TERM MEASUREMENT NEEDS



SOLAR OUTPUT

EARTH RADIATION BUDGET

AEROSOLS

CLOUDS

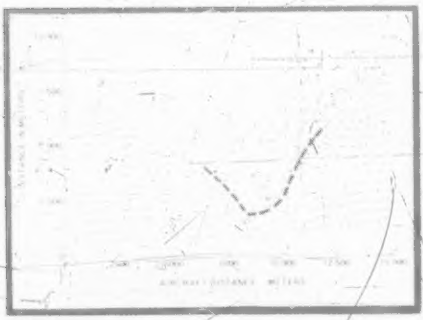
ATMOSPHERIC COMPOSITION

OCEAN HEAT TRANSPORT

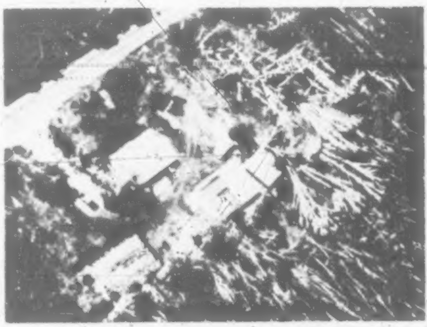
SNOW/ICE COVER

PRECIPITATION

WEATHER AND SEVERE STORMS LIDAR TECHNIQUE DEVELOPMENT

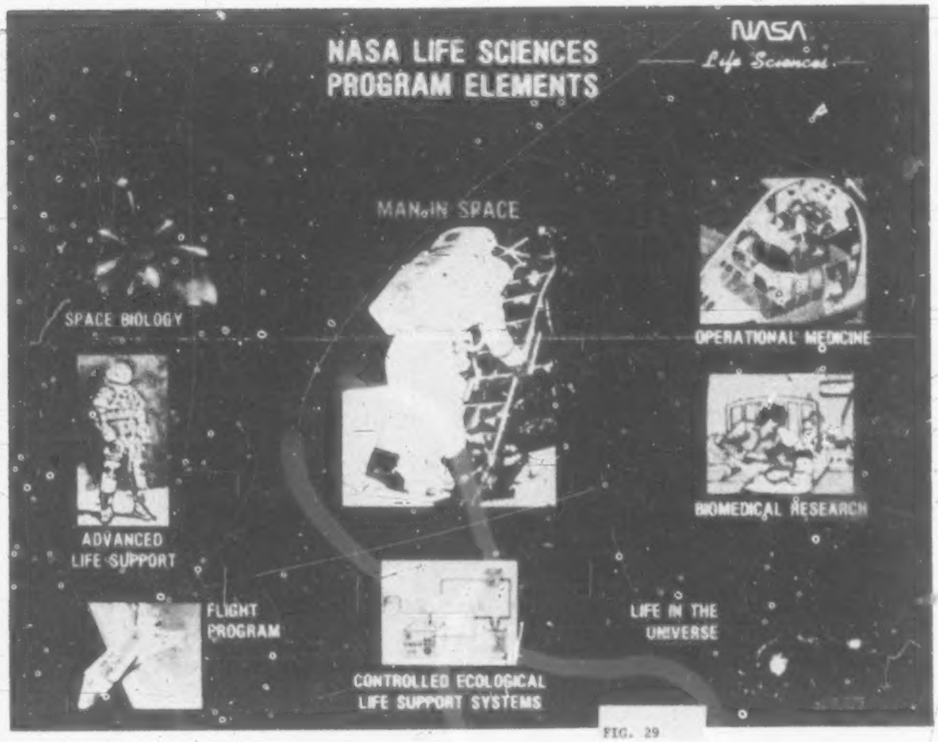


AIRCRAFT LIDAR WIND VECTOR MEASUREMENTS SHOWING GUST FRONT



GUST FRONT EFFECTS

FIG. 28



NASA LIFE SCIENCES PROGRAM ELEMENTS

NASA
Life Sciences

MAN IN SPACE

SPACE BIOLOGY

OPERATIONAL MEDICINE

ADVANCED LIFE SUPPORT

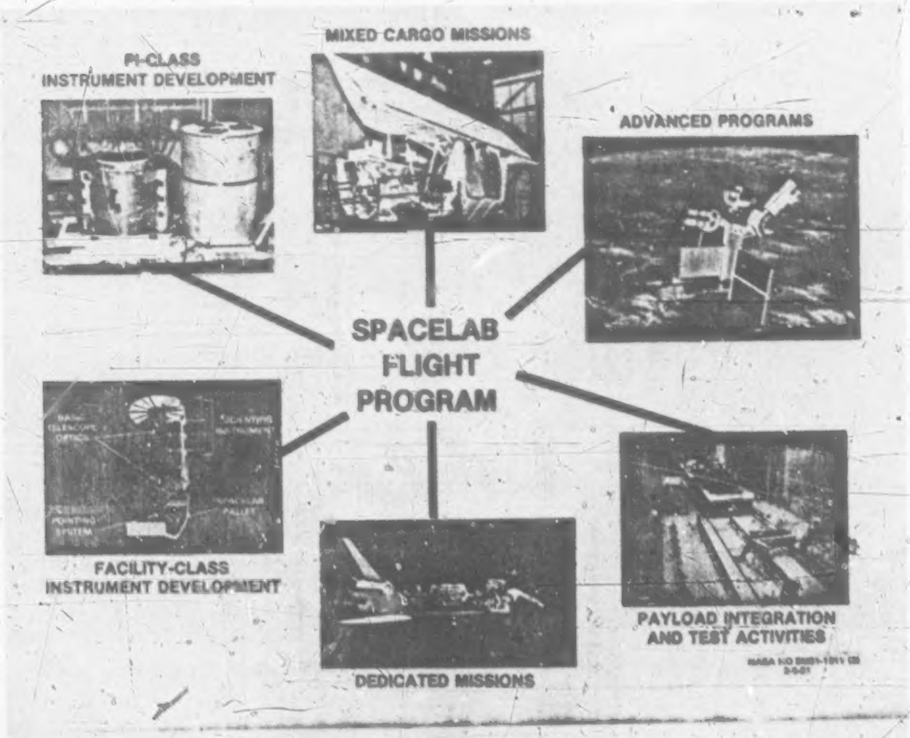
BIOMEDICAL RESEARCH

FLIGHT PROGRAM

CONTROLLED ECOLOGICAL LIFE SUPPORT SYSTEMS

LIFE IN THE UNIVERSE

FIG. 29



MIXED CARGO MISSIONS

PI-CLASS INSTRUMENT DEVELOPMENT

ADVANCED PROGRAMS

SPACELAB FLIGHT PROGRAM

BASIC TELESCOPE OPTICS
SCIENTIFIC INSTRUMENT
POINTING SYSTEM
SPACELAB PALLET

FACILITY-CLASS INSTRUMENT DEVELOPMENT

DEDICATED MISSIONS

PAYLOAD INTEGRATION AND TEST ACTIVITIES

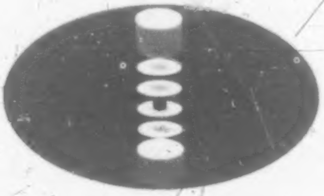
[illegible]

FIG. 30

MATERIALS PROCESSING IN SPACE

MEDICAL PRODUCTS

MICRO-CIRCUITS



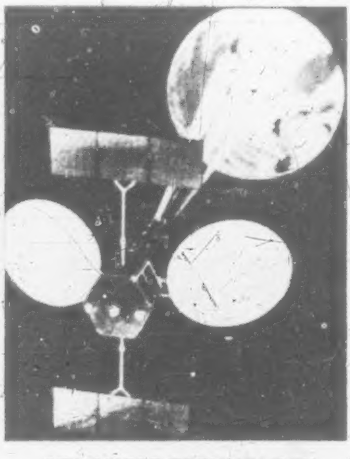
CONTAINERLESS PROCESSING

COMMUNICATIONS

STATE OF THE ART

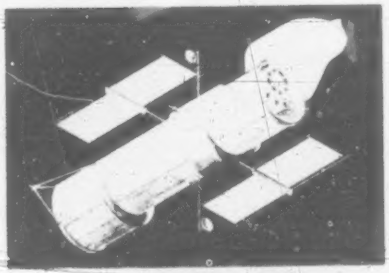
LONG
LEAD TIME

HIGH RISK
TECHNOLOGY

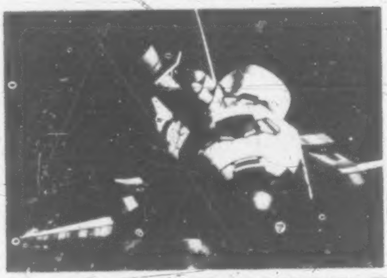


ADVANCED TECHNOLOGY

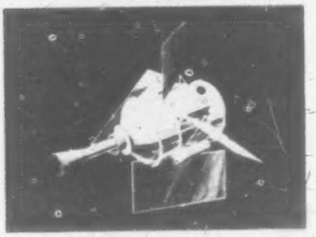
ADVANCED STUDIES
THE UNIVERSE AND THE SOLAR SYSTEM



ADVANCED X-RAY
ASTROPHYSICS FACILITY



SHUTTLE INFRARED TELESCOPE FACILITY

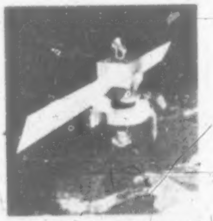


GRAVITY PROBE B

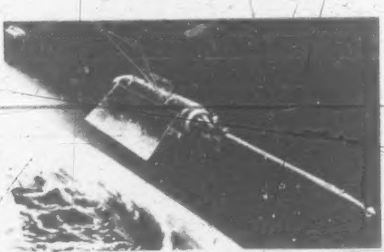
SOLAR SYSTEM

ADVANCED STUDIES
THE EARTH AND THE EARTH'S ENVIRONMENT

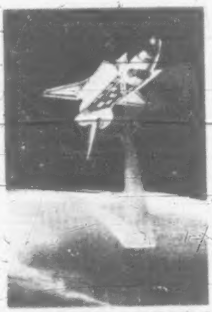
ORIGIN OF PLASMAS IN THE
EARTH'S NEIGHBORHOOD



OCEAN EXPERIMENT
TOPOGRAPHY



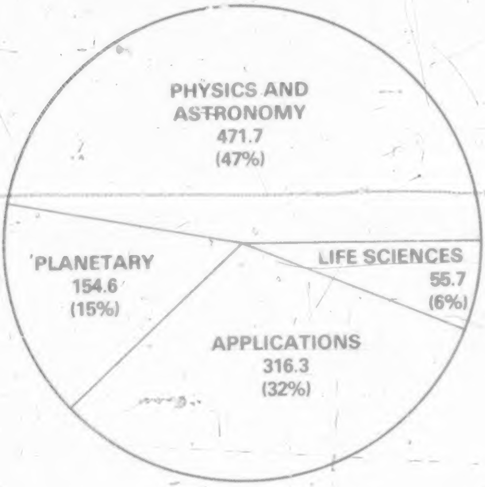
GRAVITY AND MAGNETIC SATELLITE



MULTISPECTRAL LINEAR ARRAY

OFFICE OF SPACE SCIENCE AND APPLICATIONS RESEARCH AND DEVELOPMENT BUDGET

(DOLLARS IN MILLIONS)



$998.3

FIG. 35

SANTA YNEZ RANGE, CALIFORNIA

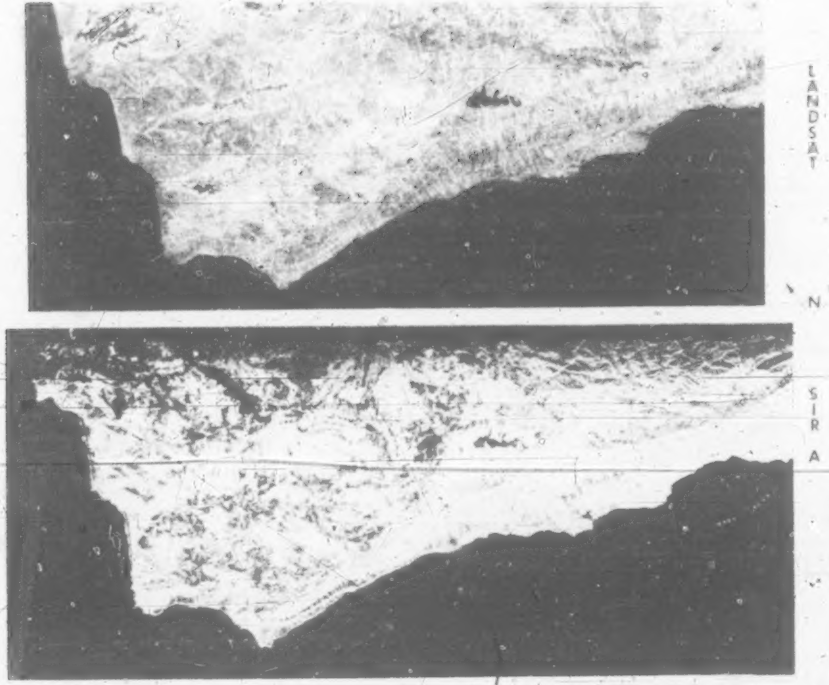


FIG. 36

[The following information was subsequently received for the record:]

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR CANNON

DECLINE IN THE APPLICATIONS PROGRAM IN NASA

Question: NASA's budget for Space Applications for the period FY 1980-1983 has been as follows (in constant FY 1983 dollars):

FY 1980	$608 Million
FY 1981	$547 Million
FY 1982	$499 Million
FY 1983	$456 Million

Do you think this decline will continue? Is this trend in the Nation's best interest?

Answer: Much of the decline reflects the inflation that the Nation has suffered which we are hopeful will not continue; moreover, this funding level cannot be viewed in isolation. The President's Economic Recovery Program is expected to provide a strong economic base for future private investment in space applications. NASA will continue to invest selectively in those areas where industry cannot be expected to invest, i.e. longer range basic research.

COMMUNICATIONS (ECONOMIC IMPACT)

Question: Last month the House Subcommittee on Space Science and Applications issued a report entitled "NASA Space Communications Program." I would like to read portions of their findings and ask you if you agree with them.

Finding No. 1. No single private company can afford to finance the large capital outlays nor bear the high risks that broad-scale space communications R&D efforts require. Do you agree?

Finding No. 2. NASA's space communications R&D has been successful. NASA's work from 1960 to 1973 provided the basic R&D on which low-risk commercial systems could be developed in the private sector. Do you agree?

Finding No. 3. The private sector should continue to be invited to participate in shaping the direction of NASA's work in 30/20 GHz R&D. Do you agree?

Finding No. 4. Without the continuation of a strong Federal R&D program, dominance by foreign countries of the strategic multi-billion dollar international communications satellite market of the 1990s is likely. Do you agree?

The report continues with the estimate that "there could be an outflow of as much as $10 to $15 billion from the United States during the 1990-2000 period for equipment purchases." Do you think this is a reasonable estimate?

Answer: NASA does, in general, agree with the findings of the House Space Science and Applications Subcommittee report, "NASA Space Communications Program." However, the terms used such as "strong

Federal R&D program" are subject to interpretation so care must be taken in applying these findings to a particular situation. The current budget does not provide for longer range R&D in communications.

The United States has, in the past, enjoyed success in the space communications market as a consequence of active R&D work in both the public and private sectors. This combination is consistent with risk postures of both sectors and as history has shown has been a very successful arrangement. Continuation of advanced technology development and its application is essential to maintaining an effective competitive posture in the face of rising foreign competition.

A possible advanced communication satellite technology development is currently being defined by NASA which includes private sector requirements for 30/20 GHz system component technology development.

Current assessment of the future market for communication satellites and related equipment, both domestic and foreign, estimates that the total market through the year 2000 will be approximately $35 billion. The United States has enjoyed a large share of the satellite communications market; however, that share may diminish as a result of competition from both Europe and Japan, but this does not necessarily mean that the United States would purchase 30/20 GHz equipment from abroad, thus it does not mean the United States would have a net outflow. It is the policy of this Administration that the best way to insure strong R&D is to provide good economic conditions for industry and to remove Government constraints.

COMMUNICATIONS (DOD VS. NASA)

Question: How does the technology to be used in the DOD's Milstar program differ from the technology NASA proposed to test in their examination of advanced communications satellites, specifically in the program referred to as the "30/20 GHz program?" Would there be any duplication of effort? Would you expect any significant technology transfer from the DOD program for commercial purposes?

Answer: The DOD's Milstar program is designed to provide reliable and secure tactical mobile communications to units in the field. The requirement is for low data rate communications to mobile terminals with the system having very high anti-jam capability. The total capacity of the system is measured in megabits/second.

The requirement for commercial communications is characterized by high data rate flow among fixed terminals. There is no requirement for anti-jam capability. Total capacity of commercial satellite systems is measured in gigabits/second total capacity, with low cost/circuit the main technology driver.

Since both systems use 20 GHz as a the downlink frequency, there is synergism at the component technology level and as a result an active cooperative program exists between DOD and NASA to develop the component technologies at this frequency. The uplink frequencies, 30 GHz for commercial and 44 GHz for Milstar, are markedly different and require different component technologies. The technologies relating to antennas and satellite switching are very different in the component technologies as a result of the system data rate differences and the application in Milstar to mobile use and in the

NASA system to fixed satellite service technologies. Despite the application differences, benefits can be derived from cooperative programs in these technology developments.

Since a major portion of both DOD and NASA funded technology development is usually accomplished in industry, a natural technology transfer in both directions occurs with both agencies benefiting. Duplication of effort other than that planned for the purpose of seeking competitive sources for the component technologies is all but eliminated as a consequence of our close cooperation.

COMMUNICATIONS (NASA'S BUDGET)

Question: NASA's budget for communications was $22 million in FY 1981, $16 million in FY 1982, and $12 million requested in FY 1983. In other words, NASA proposes to spend only 1 percent of its Science and Applications budget (or just 0.2 percent of the total NASA budget) for communications. This is so even though communications has been and will continue to be the most economically important benefit for the United States space program.

How can this Administration justify this budget proposal and termination of the 30/20 program when economic recovery is the number one objective today?

Answer: NASA's FY 1983 budget request does not terminate the ongoing 30/20 GHz program activities. NASA will complete the proof-of-concept hardware development which is a necessary precursor to any flight development program. The Administration's position is that a flight demonstration of the 30/20 GHz capability is a not a proper role for NASA. The President's program is expected to provide a strong economic base for future private investment by the U.S. communications industry. The NASA communications program is presently being redefined to emphasize those activities of a research and development nature which are within the proper scope of Government activity.

LANDSAT

Question: NASA's budget contains no money for Landsat beyond -D and -D' because the Administration indicates that it will spinoff the Landsat system to the private sector.

It has been a year now, and we have not seen any Administration proposals to transfer the system to the private sector.

(a) What is the status of the Administration's efforts?
(b) What evidence does the Administration have that the private sector will want to pick up the system unless they receive a guaranteed market and/or subsidies?

Answer: (a) A Cabinet Council has been formed to look into the possible transfer of the land remote sensing effort to the private sector, and it has deliberated on the issue to some extent, but to date no definitive consensus has emerged.

(b) While there are indications of interest in picking up the land remote sensing effort, to date there has been no detailed proposal from the private sector. However, it is our belief that if the value of the data to the user is sufficient, then there will be an incentive for the private sector to pick up these efforts.

MATERIALS PROCESSING

Question: Are you satisfied that NASA's budget in the Materials Processing area is sufficient to take advantage of the economic opportunities associated with this new field? What was NASA's original request to OMB in Materials Processing?

Answer: NASA's support for basic science in Materials Processing in Space (MPS) is continuing through ongoing research with over 70 principal investigators in university, industrial, and Government laboratories. New science has been initiated by "pruning off" that part of the existing effort where prior research indicates a diminishing contribution to program goals.

Preservation of hardware capability is being maintained by upgrading existing sounding rocket payloads so that they can be flown on the Shuttle. We also plan to investigate the sharing of hardware with foreign MPS programs such as Germany and France who may have complementary payloads.

In addition, we also support a commercialization program, which has produced two Joint Endeavor Agreements (JEA) and three Technical Exchange Agreements (TEA).

NASA requested $29.5 million from OMB for Materials Processing in Space in FY 1983.

TECHNOLOGY UTILIZATION

Question: The benefits of NASA's Technology Utilization program are widely recognized. It tries to apply already developed space technology to new markets and public needs, and its benefit/cost ratio has been quite high. Why is funding for this program being cut again?

Answer: The reduced level of Technology Utilization funding requested for FY 1983 assumes that the private sector can and should provide a number of the services of this program area in the future.

QUESTIONS SUBMITTED FOR THE RECORD BY CHAIRMAN SCHMITT

REORGANIZATION PLANS

Question: Would you please describe any further reorganization plans that you have for the Office of Space Science and Applications? Why are materials processing and information systems located directly under your office as opposed to at a division level?

Answer: The Office of Space Science and Applications was established on December 3, 1981 as part of the overall NASA reorganization. At this time, no plans for further reorganization are being considered.

The Materials Processing in Space and the Information Systems Offices were established as reporting offices to the Associate Administrator as a matter of administrative practicality. In both cases it was determined that the personnel complement and budget allocation were not of sufficient size to warrant separate Divisions; yet each function is sufficiently important to the overall Science and Applications Program to warrant a separate reporting entity with immediate and direct access to the Associate Administrator.

MATERIALS PROCESSING PAYLOAD DEVELOPMENT

Question: What will be the impact of the reduction of funding to the Shuttle/Spacelab materials processing payload development budget from $8.8 million in FY 1982 to $3.3 million in FY 1983? Is it assumed that industry will pick up funding for this area?

Answer: The reduction of the Shuttle/Spacelab materials processing payload development budget in FY 1983 from the FY 1982 level reflects the planned phasedown of TRW efforts in the building of the Fluid Experiments System/Vapor Crystal Growth Hardware (FES/VCG). Funds requested in FY 1983 will be used to continue science support for Shuttle payloads, and to build a small shuttle-compatible furnace for conducting solidification studies in low gravity. No assumption has been made regarding the private sector picking up materials processing payload development efforts.

RESEARCH AND ANALYSIS FUNDING

Question: In your view are we putting enough money into analysis of data from current satellites, basic research and advanced planning to be certain that NASA Space Science and Applications has a viable future? What do you see as the consequences of the current funding level trends for the mission operations and data analysis and research and analysis budgets?

Answer: The FY 1983 budget request provides for the maintenance of a viable data analysis and research program. Planned activity in some areas had to be curtailed, stretched out, or in some cases eliminated. However, the FY 1983 budget will support a viable core program that provides for NASA priority activities in this area.

NASA COMMUNICATIONS PROGRAM

Question: The FY 1981, FY 1982, and FY 1983 budgets for communications and information systems are $31.2, $20.9 and $19.9 million, respectively, representing a significant reduction in the program. What do you see as the value of the NASA Communications Program and why the reduction? How do you see the United States facing the competition from foreign countries with a reduction in communications research support?

Answer: NASA's current program in communications is being restructured to concentrate on advanced satellite communications technology thus the program will continue to be of great value to NASA, other government agencies, and U.S. industry in developing advanced technology requirements. The Communications program funding was reduced in FY 1982 and FY 1983 based on the belief that some of the planned technology efforts are at such a stage of maturity that they can be picked up by the private sector and the policy not to pursue large hardware demonstrations. We do understand that the Japanese government has greatly increased their support of Japanese industry in this area, however, this competition may not necessarily be unhealthy for the U.S. as we are continuing many of our planned Communication efforts.

COMMUNICATIONS FUNDING

Question: Supposing that this Congress directed that more funds be devoted to communications in FY 1982 and FY 1983, what would be your reaction? Is the agency supportive of a healthy research and development program in communications?

Answer: It would be inappropriate to plan for the use of funds that are in excess of the President's budget. NASA is supportive of a healthy research and development program in communications; however, we believe that we have developed a viable program.

UARS PROGRAM

Question: Please describe the UARS program in more detail and give us a rough idea of the magnitude of the project which is being contemplated? Does the $14 million requested for FY 1983 constitute support for phase B activities or does it constitute essentially a new start for this program?

Answer: The potential Upper Atmospheric Research Satellite (UARS) Program consists of two major segments:

- UARS-Experiments (UARSE)
- UARS-Mission (UARSM)

The FY 1983 funding of $14.0 million supports the UARS-Experiment development activities only, and the UARS Mission funding (satellite and ground system) requirements will be addressed as a new start by NASA in a future budget.

The scientific objectives of the UARS Program are (1) to understand the mechanisms that control upper atmosphere structure and variability, (2) to understand the response of the upper atmosphere including the ozone layer to natural and man-related perturbations, and (3) to understand the role of the upper atmosphere in climate and climate variability.

The runout estimate for the UARS experiments is $200-300 million. An estimate has not yet been developed for the spacecraft and ground system; consequently, a detailed estimate of the total project cost has not yet been developed.

FY 1983 requested funding of $14.0 million for UARSE will be used to continue instrument development and definition and design efforts on the ground data handling facility, and initiate detailed implementation studies for a future UARS-Mission.

EXPLORER PROGRAM

Question: What has been the impact of the level budget for Explorers on the initiation of new development activities? How would you assess the success of the Explorer program during the last five years as compared with the major hardware development programs?

Answer: The level Budget for Explorers has allowed approximately one new mission to be initiated every three years. The success of the Explorer program competes very well with the major hardware development program. For example, the Explorer program has provided timely and valuable results in all of the following areas: Astronomy, Astrophysics and Solar Terrestrial Physics. The program provides a unique capability to address specific scientific questions and complement the broad scientific goals of the major flight projects. Generally, the explorers are inexpensive and have short development times so that the data returned serve to better define the mission goals for the major hardware development programs.

SPACE TELESCOPE DEVELOPMENT

Question: What would you describe as the most significant development problems to date on the Space Telescope program? Have the major technical goals of this program changed since the beginning of the program? If so, how?

Answer: The most significant development problems to date on the Space Telescope (ST) program have been associated with the Optical Telescope Assembly (OTA) and the Pointing Control Subsystem.

Polishing of the 2.4 meter (94.5 inch) primary mirror, and design, fabrication, and assembly of the focal plane structure have been significant development problems. The primary mirror represents one of the biggest technical challenges to the ST Program; however, a significant milestone was accomplished by the successful completion in December 1981 of the polishing and coating of the primary mirror. In addition, thermal expansion considerations required a change in the material of the focal plane structure from titanium to graphite epoxy. Structural strength problems with the new focal plane structure still remain, and satisfactory solutions are presently being pursued.

Another area of concern and one of the most difficult of the remaining technological hurdles of the ST Program is meeting the stringent requirements for pointing and stability. An extensive redesign of the fine guidance sensor has resulted in additional cost and schedule concerns regarding the timely delivery of the Optical Telescope Assembly. Modifications to the rate gyros have recently been initiated to help insure meeting the 24-hour stability requirements of 0.007 to 0.012 arc seconds of angle.

The scientific goals of the ST Program have not been changed since the program was intiated and none are expected.

GAMMA RAY ASTROPHYSICS

Question: What plans do other countries have to compete with the U.S. in the area of Gamma Ray astrophysics?

Answer: France and the USSR are the major U.S. competitors in gamma ray astrophysics. Both countries have collaborated on a series of gamma ray burst instruments on the Prognoz spacecraft, on the Venera probes to Venus and on a small high energy gamma ray spacecraft called Gamma-1. Gamma-1 is very similar to the second Small Astronomy Satellite launched by NASA in 1972 and the European Space Agency satellite, COS-B, launched in 1975. Gamma-1 is scheduled for launch by the Soviet Union in 1983. France is also planning a national gamma ray spacecraft, called SIGMA, for launch on the Ariane IV demonstration flight in the 1985/86 time frame. The planned payload for SIGMA is a low energy gamma ray imaging device which will be sensitive to gamma rays from 30 keV to 2 MeV. The instrument will incorporate a coded aperture collimator for source location.

A French research group has developed capability to perform high resolution gamma ray spectroscopy, and much of the research by this group is carried out in collaboration with U.S. groups. The Federal Republic of Germany also has several active gamma ray astrophysics research groups. Two of these groups are presently participating with U.S. groups on instrumentation to be flown on the Gamma Ray Observatory. The German groups also fly gamma ray instrumentation on U.S. high altitude research balloons.

Japan has an active interest in gamma ray astrophysics, but does not have a highly developed research capability. However, they are considering flying a gamma ray burst instrument on a Japanese x-ray astronomy spacecraft to be launched in 1987. It is possible that this instrument would be provided by a German or British research group. Great Britain and Italy also have active gamma ray astrophysics research groups, but they limit their research primarily to high altitude balloon flight opportunities.

SOVIET LARGE TELESCOPE

Question: Recent statements by the Soviets suggest that they are working on a large telescope for scientific purposes. Are you aware of such activities and can you provide us with more details?

Answer: It is our understanding that the Soviet Union has been, for the last two years, conducting studies to define a concept of a 2.5 meter optical telescope. This telescope is believed to be a segmented mirror with an attitude azimuth mount.

TRANSFER OF NATIONAL BALLOON FACILITY

Question: What is the impact of the transfer from the National Science Foundation to NASA of the National Balloon Facility?

Answer: The transfer of the National Scientific Balloon Facility, located in Palestine, Texas, from the National Science Foundation to NASA is being negotiated, but has not yet been accomplished. If the transfer is effected, NASA is planning to fund the National Scientific Balloon Facility (NSBF) at its present level (approx. $3 million per year).

SOLAR MAXIMUM MISSION DATA

Question: What data are currently being received from SMM, from which instruments and where are these data going? How would this situation change if SMM were to be repaired?

Answer: Three of the seven SMM instruments are now receiving and returning data. These instruments are as follows:

1) The Gamma Ray Spectrometer, is being used to study radiations from nuclear reactions and accelerated particles in solar flares. The Principal Investigator and his team are located at the University of New Hampshire, and the data are sent there from Goddard Space Flight Center for analysis. Other teams of scientists involved with this investigation who also receive and analyze these data are located at the Naval Research Laboratory in Washington, DC and at the Max Planck Institute in Munich, West Germany.

2) The Hard X-Ray Burst Spectrometer is being used to observe the detailed time signatures of flare bursts caused by groups of electrons suddenly accelerated to very high speeds. The team for this experiment is located at Goddard Space Flight Center and receives the data there.

3) The Active Cavity Radiometer Irradiance Monitor (ACRIM) is under the direction of Dr. Richard Willson of the Jet Propulsion Laboratory (JPL) in Pasadena, California and the data are analyzed at JPL. This instrument is being used to study variations in the amount of total solar energy reaching the Earth from the Sun.

After repair of the SMM, data from six of the experiments will come into the Experiment Operations Facility at the Goddard Space Flight Center where representatives of all of the flare experiment teams will be located. Initial analysis of the data will be done at Goddard, and then the data will be sent to the teams' home institutions for in-depth analysis. (Representation at Goddard by the Dutch and New Hampshire experiment teams may not be full-time, but will be substantial.) The Active Cavity Radiometer Irradiance Monitor data will continue to be forwarded to JPL for analysis by Dr. Willson.

OPERATING SATELLITES

Question: Would you please summarize for the record:

- current satellites still operating,

- satellite missions under active phase C/D development,
- programs in phase B definition stage and under active consideration for new starts.
- all other programs in the early advanced planning stages on which you are spending money.

Please provide a short description of the program so far as it is known and a current status.

Answer: A list of the currently orbiting satellites which are still operating follows:

Physics and Astronomy

IMP-8 (Interplanetary Monitoring Probe-8)
Launch: October 26, 1973 Projected reentry: 1987

ISEE-1 (International Sun Earth Explorer-1)
Launch: October 22, 1977 Projected reentry: 1987

ISEE-2 (International Sun Earth Explorer-2)
Launch: October 2, 1977 Projected reentry: 1987

ISEE-3 (International Sun Earth Explorer-3)
Launch: August 12, 1978 Projected reentry: N/A

IUE (International Ultraviolet Explorer)
Launch: January 26, 1978 Projected reentry: Undefined

SMM (Solar Maximum Mission)
Launch: February 14, 1980 Projected reentry: 1987

DE-1 (Dynamics Explorer-1)
Launch: August 3, 1981 Projected reentry: Undefined

DE-2 (Dynamics Explorer-2)
Launch: August 3, 1981 Projected reentry: 1982-83

Earth and Planetary Exploration

Pioneer-6	Launch: December 16, 1965
Pioneer-7	Launch: August 17, 1966
Pioneer-8	Launch: December 13, 1967
Pioneer-9	Launch: November 8, 1968
Pioneer-10	Launch: March 3, 1972
Pioneer-11	Launch: April 6, 1973
Viking I Lander (Mutch Memorial Station)	Launch: August 20, 1975
Voyager 1	Launch: September 5, 1977
Voyager 2	Launch: August 20, 1977
Pioneer Venus	Launch: May 20, 1978
Landsats-2 and -3	Launch: January 1975 and March 1978

Environmental Observations

Nimbus 5	Launch: December 1972
Nimbus 6	Launch: June 1975
Nimbus 7	Launch: October 1978
Stratospheric Aerosol and Gas Experiment	Launch: January 1979

Communications

ATS-1	Launch: December 7, 1966
ATS-3	Launch: November 5, 1967
ATS-5	Launch: August 12, 1969

The following missions undergoing active development efforts currently:

- Space Telescope - Launch scheduled for 1st half of 1985.
- Gamma Ray Observatory (GRO) - Launch scheduled for late 1988.
- Explorers:
  - Cosmic Ray Isotope Experiment (CRIE) - Launch scheduled for late 1982.
  - San Marco D (SM-D) - Launch scheduled for 1982.
  - Infrared Astronomy Satellite (IRAS) - Launch scheduled for 1982.
  - Active Magnetospheric Particle Tracer Explorer (AMPTE) - Launch scheduled for 1984.
- Earth Radiation Budget Satellite (ERBS) - Launch scheduled for 1984.
  - Galileo - Launch scheduled for 1985.
  - Landsat-D and -D' - Launch scheduled for 1982 and 1985.
  - Search and Rescue - Launch scheduled for 1982.

The following projects are currently in the definition stage:

- Gravity Probe-B (GP-B)
- Explorers:
  - Cosmic Background Explorer (COBE)
  - Extreme Ultraviolet Explorer (EUVE)
- Ocean Topography Experiment (TOPEX)
- Advanced Communications Technology Satellite
- Solar Optical Telescope (SOT)

The following programs are in the early definition stage:

- Venus Mapping Mission
- Advanced X-Ray Astrophysics Facility (AXAF)
- Large Deployable Reflector (LDR)
- Orbiting Very Long Baseline Interferometry (OVLBI)
- Starprobe
- Coherent Optical System of Modular Imaging Collectors (COSMIC)
- Solar Beacon
- Origin of Plasmas in Earth's Neighborhood (OPEN)
- Advanced Solar Observatory (ASO)
- Cosmic Ray Mission Planning
- Explorers:
  - X-Ray Timing Explorer (XTE)
  - Far Ultraviolet Spectroscopy Explorer (FUSE)

- Spacelab/Space Station
  - Shuttle Infrared Telescope Facility (SIRTF)
  - Pinhole Occulter Facility
  - Starlab
- Upper Atmosphere Research Satellite
- Solar Internal Dynamic Mission (SIOM)

AgRISTARS PROGRAM

Question: What do you think will be the future of the AgRISTARS program? How much do NOAA and the Department of Agriculture contribute to this program? What did the Department of Agriculture contribute in FY 82? What gives you the confidence that the Department of Agriculture will pick up the pilot testing activity terminated by NASA?

Answer: The NASA AgRISTARS program now emphasizes the research and development necessary to identify and validate basic techniques for extracting useful information from remotely sensed data to inventory vegetation types and assess their condition. The FY 1983 budget for AgRISTARS assumes that the large scale testing and operational capability of these techniques will be funded by the Department of Agriculture (USDA).

Future NASA involvement in the AgRISTARS program will depend on the ability of the different agencies to adopt the techniques developed by NASA.

The Department of Agriculture budgeted $12.5 million in FY 1982, and $12.9 million in FY 1983 for the AgRISTARS program; NOAA has budgeted $3.1 million in FY 1983. When the AgRISTARS program was initiated, each participating agency agreed to budget for its respective portion of the program. Since NASA has the capability and expertise in the development and initial testing of new remote sensing techniques, most of the early AgRISTARS program was funded by NASA. Our current planning assumes that the Department of Agriculture will conduct most of the large scale testing of the basic techniques developed by NASA.

CRUSTAL DYNAMICS REDUCTIONS

Question: What were the impacts of the FY 1982 reductions on the crustal dynamics programs? Will any of these decreases be offset in FY 1983?

Answer: The NASA Geodynamics program is strongly focused towards cooperative activities involving other countries. This is a natural consequence of the global nature of geodynamics, the need to observe different tectonic situations, the interest of the United States and other countries in understanding crustal hazards, and the desire on our part to spread the costs of this research. The program directly involves 19 countries. In addition, several other countries are included through projects initiated by international scientific organizations and some of these countries have built systems similar to those developed by NASA and are participating in global measurements. Other countries currently have systems under development. The FY 1982 budget reductions resulted in a general reduction in some planned international efforts such as a general decrease in the extent of global studies and a delay in the planned implementation of new study efforts. The FY 1982 reductions are not planned to be offset in FY 1983.

IUS/CENTAUR

Question: There has been a lot of discussion on the issue of the IUS/Centaur/High Energy Upper Stage problem in recent months. At this point in time if we were to choose to put the success of the ISPM and Galileo missions as our primary goals and ignored larger questions such as DoD's need for a high energy upper stage, what would be your recommendation as to how NASA ought to proceed right now?

Answer: NASA's FY 1983 budget request assumes the Galileo and ISPM will be launched in 1985 and 1986, respectively, on the Air Force two-Stage IUS because of the maturity of Galileo and ISPM as well as the Inertial Upper Stage. Therefore, we believe it is in the best interest of both of these projects to continue in this direction.

GALILEO/ISPM INCREASES

Question: What accounts for the FY 1983 Galileo/ISPM increases? If these missions were to be flown on a Centaur would the development costs for the upper stage be charged to the Office of Space Science and Applications?

Answer: The increase in FY 1983 for Galileo and ISPM development is directly related to the change from the Centaur upper stage to the Inertial Upper Stage launch mode. The increase is required for the initiation of a kick stage development to accommodate integration of both of these spacecraft with the IUS.

These increases were assigned to the Office of Space Science and Applications in the interest of cost and management effectiveness since the requirements of the kick stage are more closely aligned to the mission spacecraft than to the upper stage. Development costs for the Centaur would not be charged to the Office of Space Science and Applications; such development efforts would be charged to the Office of Space Transportation Systems.

OCEANIC SATELLITE MISSIONS

Question: Do plans exist for future oceanic satellite missions such as NOAA and SEASAT?

Answer: The goal of NASA's Oceanic Processes program is focused on evaluating the utility of spaceborne techniques for observing the oceans and applying these techniques in advancing our understanding of the fundamental behavior of the oceans. Therefore, we are concentrating on those satellite ocean sensors with the greatest near-term potential for allowing a better understanding of the fundamental behavior of the oceans. In addition, we are assessing the various flight options for those sensors. For example, we are studying the possibility of a dedicated spacecraft for the altimeter to determine the general circulation (or current structure) of the global oceans. Not only will an improved understanding of the oceanic circulation and the associated redistribution of heat help assess the influence of the oceans on atmospheric climate, but information on the global wind and wave field will be useful to the operational users.

We are also studying the feasibility of deploying a scatterometer and/or a color scanner aboard the NOAA series of operational meteorological spacecraft. The scatterometer would map the surface wind field. The color scanner, which maps chlorophyll concentration associated with phytoplankton, can possibly contribute to our understanding of primary productivity in the oceans. Information from these two sensors may also contribute to atmospheric weather forecasting and fisheries management.

In addition. we are investigating the NASA needs for the scientific data from the Air Force's microwave radiometer aboard the Defense Meteorological Satellite Program (DMSP) series of operational meteorological satellites; from the Navy's altimeter aboard Geosat; and from the Navy's Remote Ocean Sensing System (ROSS). We are also conducting preliminary discussions with (1) the European Space Agency regarding having access to data from the synthetic aperture radar (SAR), scatterometer, and altimeter to be launched on their ERS-1 spacecraft, scheduled for launch in 1987, (2) the Canadians regarding the SAR aboard their Radarsat, scheduled for 1990, (3) the Japanese regarding data from their MOS-1.

LIFE SCIENCES SUPPORT

Question: How do you see support for the life sciences programs changing in the next few years if NASA begins development of a permanent manned presence in space?

Answer: Permanent manned presence in space involves a serious repsonsibility as well as a tremendous opportunity for research for Life Sciences. For example, life support systems will be needed which can recycle air and water to minimize the need for resupply. Medical care will have to be delivered in space rather than before and after a short mission.

In addition, opportunities for research will be abundant due to the long duration in space provided by a space station. While the Life Sciences program strongly supports use of the Shuttle/Spacelab for scientific understanding of physiological problems in man and for research into the effects of gravity on living organisms, there remain a number of questions that require longer mission times in zero gravity. For example, the growth and development of organisms without gravity can only be studied with longer missions. Loss of bone and muscle mass, and the deconditioning of the heart and blood vessels can be studied more effectively with man spending longer periods of time in space.

ARCTIC ICE FIELDS MAPPING

Question: The Canadian government recently proposed a joint satellite program to map the Arctic ice fields on a continuing basis, but the United States decided not to participate. Do you know why this occurred?

Answer: The Canadian government and NASA have been conducting a joint mission requirements study for a potential future satellite which would involve a Synthetic Aperture Radar Instrument as the primary sensor to map the Arctic Ice fields and their continual changes. Among the scientific research tasks that would be addressed by such a mission is the understanding of the dynamics of the arctic sea ice and the fluctuations in the ice margin. Science working groups are examining the usefulness of such a mission to the areas of oceanography, renewable resources and non-renewable resources. The Canadian studies for such a mission are in the conceptual design phase and the Canadian government is aggressively pursuing international cooperation. NASA is currently examining possible participation in such a mission, but a decision has not yet been made.

MATERIALS PROCESSING ASSESSMENT

Question: How would you assess the success of the materials processing in space program to date?

Answer: The major goal of the Materials Processing in Space program is to establish a base of scientific data and a basic understanding of the role of gravity in the processing of materials. Progress in the difficult task of involving and educating the scientific community is best measured, we believe, by noting that the annual number of peer-reviewed MPS scientific publications has gone from less than five in the early 1970's to about 70 in 1981.

Flight opportunities to provide experimental data have been less than assumed in the 1970's; however, with the operational phase of the Shuttle, we are looking forward to the receipt of new data from a number of experiments which will be flown in the next few years.

SOLAR OPTICAL TELESCOPE DEVELOPMENTS

Question: When do you expect to begin development of the Solar Optical Telescope?

Answer: NASA's current plan is to select the Solar Optical Telescope (SOT) contractor this year. Design and development of the scientific instruments was initiated and is currently under development.

PIONEER SPACECRAFT SUPPORT

Question: How can you justify turning off the existing Pioneer satellites to save money when the planetary community can look forward to only a very bleak future for missions beyond Galileo?

Answer: The FY 1983 Planetary Mission Operations and Data Analysis funding will continue support for Voyager encounter with Uranus. However, the Pioneer spacecraft support may have to be terminated. However, NASA is examining the impact of such action and no decision has been made. It is not pleasant to consider the potential loss of science which will be caused by these potential terminations, however we believe that the existing Planetary mission operations and data analysis funds are best spent on continuing Voyager operations and preparing for Galileo operations.

Mr. GORTON. We will hear now from Mr. Minato, after his sterling introduction by Senator Packwood.

You may proceed.

STATEMENT OF JOSEPH R. MINATO, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Mr. MINATO. Thank you, Senator.

I have prepared a written statement for the record.

Senator GORTON. That will be included in the record in full.

Mr. MINATO. At first glance it would appear that the U.S. space program is flourishing. Unfortunately, from the perspective of a young science student, the space program is in severe trouble. NASA funding for data analysis of past projects has been steadily decreasing. Combined with the severe lack of new scientific projects, this makes the university prospects for space science research look pretty bleak.

The last space probes were the Voyager twins launched in 1977. The next is Galileo in 1988. Astrophysical research has also decreased.

The specific disadvantages of limiting the NASA space science budget are clear, and I am sure you are well aware of these; however, the long-term effects are less obvious. It is these long-term problems that I would like to focus on for a moment.

At the universities, the shortage of funds for basic research in the space sciences results in several problems. Projects are canceled and discontinued, while new ones never materialize. Graduate students do not have the hardware or data available to do the research at the high level of quality of which they are capable, and undergraduates are turned away from space science.

The canceling of projects has the disadvantage of limiting current and future scientific progress. One of the reasons for this is that space science, like most research, takes large amounts of time. The Voyager spacecraft were still gathering data last year in the vicinity of Saturn. With luck, Voyager II will continue on to increase our knowledge of Uranus in 1986.

By failing to initiate projects now, space science in the future will suffer. In the past, NASA support of universities has allowed graduate students the opportunity to work firsthand on scientific experiments. With a lack of support, these graduate students will be forced to undertake other, perhaps scientifically less beneficial projects.

Because of declining support for science, undergraduates also encounter difficult problems, as I am personally very well aware. Careers in science are less financially rewarding than careers in engineering. Students graduating from MIT with a bachelor's degree in engineering receive substantially higher salaries than science graduates with doctorates; however, in the sixties when Government support of science was at a peak, many students were drawn into scientific careers by the exciting opportunities to participate in the exploration of the universe and the making of discoveries.

Since the decline of scientific support, however, MIT is producing more engineers and fewer scientists. MIT is not atypical in this respect. In addition to receiving higher salaries after fewer years of school, engineering students find it much easier to arrange term-time and summer employment.

MIT has several industrial liason programs to help engineering students obtain summer jobs. Although MIT has an undergraduate research program for science and engineering students, it is, unfortunately, becoming increasingly difficult to arrange projects in the sciences, specifically space science, because of a lack of Government support for such research.

If this trend continues, more students will turn away from science to engineering, and this in turn will decrease the supply of qualified scientists and science educators in the future.

The problem is summarized in a statement by the Space Science Working Group. The Space Science Working Group is composed of 18 universities and a few other independent research institutions. Last month they issued the following statement:

> Further cuts as proposed in fiscal year 1983 will irreversibly damage space science in universities because there are no alternative ways to support the undergraduate students, graduate students, post-doctoral research associates, engineers and technicians who carry out space science projects under the direction of faculty members.

They continue to state "that if the cuts proposed for fiscal year 1983 prevail, a whole generation of would-be space scientists and engineers will have to seek other careers."

Clearly the problem is significant. But you may ask how does this really harm society? Why is space science necessary? I believe this is the most important issue in these hearings, and for that reason I would like to highlight the following responses.

Perhaps the best way to illustrate to you the reasons why space science is important to America is to explain why science is important to myself and other science students. A scientific education is very expensive. Four years of undergraduate work and 3 to 6 years of graduate study, often at an expensive private institution, costs a very large sum of money. As I mentioned, the job opportunities for a Ph. D. in astrophysics don't compare to the opportunities for an engineer with a bachelor's degree.

Students like myself are accumulating sizable personal debts with little hope of large earnings in the future because we feel that science is important and exciting. It is important on a level that cannot be measured in monetary terms. To question and ultimately to try to explain the unknown is a basic attribute of human nature. To some people, the inherent drive to explain is greater than the instinct for financial security. Certainly, most of the scientists who make it through graduate school could have been successful in engineering school.

I believe that everyone has a bit of this scientific curiosity within them. Many of the same people who question the social value of fundamental research are nonetheless amazed at what science can explain. By failing to support space science and the other basic sciences adequately, we are creating scientific stagnation in our country at a time when scientific advances are particularly important.

I believe science is important simply because it increases the knowledge held by mankind. Curiosity about the unknown is a trait of humans that should never be suppressed. However, this does not imply that science cannot be justified on the basis of practical and social benefits. In fact, the social advantages of science are widespread.

Scientific activity breeds intellectual activity. A society needs scientists just as it needs engineers, politicians, doctors, and assembly line workers. Without scientists, society would suffer.

However, science also has very tangible benefits. The previous speaker illustrated some of these. The example I would like to briefly point out is the fundamental research done in the 1800's on the theories of electricity and magnetism. A chief researcher in this field was James Clerk Maxwell, who put together what came to be known as Maxwell's equations. These equations were results of entirely theoretical research. However, nearly all of today's technology is designed with theory that has its foundation in Maxwell's equations.

Our industrial society is based on the experimental and theoretical work of the past. By inadequately funding fundamental research now, we are going to harm society many years down the road.

Finally, I would like to underscore my belief, a belief widely held in the scientific community, that space science, in fact all science, is justifiable solely on the basis of advancing knowledge. Perhaps the most common argument against an active space program is the one that emphasizes the need to solve immediate problems on Earth first. But space science, I would argue, does address immediate problems. It provides jobs, increases productivity, and produces spinoff technologies.

Yet I do not want to mislead you. I am not pursuing a scientific career because I believe that my work will solve immediate social problems. I do not believe that the primary reason many scientists investigate the unknown is to feed the poor or lower the crime rate. Certainly many scientists are also concerned about such social problems. I know that I am. However, science is important to me because I have a natural desire to discover and to increase our knowledge of the universe.

Moreover, at a time when productivity and national morale are low, I believe that the instinct for discovery and the quest for knowledge can contribute positively and should be actively publicly supported.

Thank you very much.

Senator GORTON. Thank you. Let me ask you a personal question. As the result of these considerations and shifts in societal emphasis, have you ever seriously considered becoming an engineer rather than a space scientist?

Mr. MINATO. Not for a fleeting moment: I love science. Although I did take one engineering class this term because I thought it would make me a more rounded student and a better scientist. It is interesting and beneficial. But for me and for a lot of people, science is more important than financial security.

Senator GORTON. If you were counseling high school seniors today about the prospects for ultimately being able to work in the field of space science, what would you tell them?

Mr. MINATO. I would tell them that space science is a very exciting field. If they find science interesting I would encourage them to further their scientific education and to join my effort to reinvigorate fundamental sicence in America.

Senator GORTON. What role do you think is appropriate for students such as yourself and for scientists in general in the political process?

Mr. MINATO. Scientists' role, especially young scientists, is very diversified. Unfortunately, the role is not being adequately filled by either scientists or future scientists.

I think scientists have two major obligations to society: Initially, because science is important, it is necessary for scientists to insure that their research is being adequately supported. Often scientists take sufficient funding for granted.

The other obligation scientists have does not have quite as much to do with these hearings, but I will mention it because I think it is important. I believe scientists are responsible for that which they create. They have an obligation to ensure that science is being used for the benefit of mankind.

Senator GORTON. As a practical matter, in today's world there is almost certainly more interest in space science on the part of the military than there are from other aspects of the Government. Would there, in your view, be a negative reaction within the universities or the student bodies of the universities with which you are familiar if the Department of Defense increased funding for research and scholarship support for undergraduate and graduate students?

Mr. MINATO. I think there would be very mixed feelings in universities. A lot of students, having grown up with the nuclear bomb, are—either justified or not—very antimilitary.

However, there is a much more important issue to deal with. The Department of Defense-based science tends to be product-oriented. They have a specific goal: The defense of the United States for the immediate future.

However, fundamental research, as opposed to research and development takes place on a longer time scale. I do not think there would be enough Department of Defense funding in fundamental research.

I think there would be an uproar in the universities because university students tend to be antimilitary.

But the second problem, would be more important to many young students.

Senator GORTON. In that respect, how does the United States compare with the Soviet Union in mathematics, in science, and specifically in this last question to which you have addressed yourself, basic research?

Mr. MINATO. While the United States focused on big projects; Apollo, the Space Shuttle, and other outstanding efforts that built national pride, the Soviets slowed their program and have had a lot of good space science. It has not been as good as that done by the United States yet. However, they just landed a very nice probe on Venus. Their plans for the 1980's are also impressive.

I do not see American leadership in basic research as a continuing trend unless the current enthusiasm over cutting the budget dies down.

I think the Soviets do value fundamental research. However, I think in the past America has been more successful, and I believe we need to continue support to maintain this leadership.

Senator GORTON. Mr. Minato, I would like to thank you for your enlightening and most interesting testimony. We are delighted to have had your willingness to come down here to speak to us today.

Mr. MINATO. Thank you for the opportunity.

[The statement follows:]

STATEMENT OF JOSEPH R. MINATO, MIT

Last Monday, March 22nd, 1982, the launch of Space Shuttle 3 began the third mission of the world's first reusable spacecraft. At first glance it would appear that the United States space program is flourishing. Unfortunately, from my point of view, the space program is in severe trouble. To make this clear, I will first explain the position from which I view the situation. I am an undergraduate student at the Massachusetts Institute of Technology, majoring in physics, with a possible future in astrophysics. This means that although I am sincerely concerned about today's economic and scientific problems, I am also deeply interested in the status of science and government support of science in the future. I believe I am speaking for the majority of students of science and technology as well as a large number of students in general.

I first become aware of the problems in space science in October, 1980 when I began a research project at MIT's Center for Space Research. The CSR was built under a National Aeronautics and Space Administration grant in the 1960s. Many of the CSR's projects have been partically funded by NASA, including the Small Astronomical Satellite 3, the project I am now working on. As you are well aware, NASA funding for data analysis of past projects has been steadily decreasing. This, combined with the severe lack of new scientific projects, makes university prospects for space science research look pretty bleak. Professors, research scientists, and graduate students are distrurbed by this lack of support. In previous years professors had trouble finding enough undergraduates to work for them; now students are told that money no longer exists to support undergraduate research.

The last space probes were the Voyager twins launched in 1977; the next is Galileo in 1988. I do not believe that the U.S. should allow 11 years to separate the launching of space probes. Astrophysical research has also decreased. In the 1970s, NASA supported numberous satellites gathering astrophysical data and a reasonable allocation of funds for analysis of the data. The National Research Council of the National Science Foundation and NASA provided me with the most current information on both past and future projects. The decline is very disappointing.

The specific immediate disadvantages of limiting the NASA space science budget are clear, and I'm sure you are aware of these. However, the long term harms are less obvious. It is these long term problems that I would like to focus on for a moment. At the universities the shortage of funds for basic research in the space sciences results in several problems: (1) Projects are canceled and discontinued while new ones never materialize; (2) Graduate students do not have the hardware or data available to do research at the high level of quality of which they are capable; and (3) Undergraduates are turned away from space science.

The cancelling of projects has the disadvantage of limiting current and future scientific progress. One of the reasons for this is that space science, like most research, takes large amounts of time. The Voyager spacecraft were still gathering data last year in the vicinity of Saturn. With luck, Voyager 2 will continue on to increase our knowledge of Uranus in 1986. By failing to initiate projects now, space science in the future will suffer.

In the past, NASA support of universities has allowed graduate students the opportunity to work first hand on scientific experiments. With a lack of support, these graduate students will be forced to undertake other, perhaps less scientifically beneficial, projects.

Because of declining support for science, undergraduates also encounter difficult problems, as I am personally well aware. Careers in science are less financially rewarding than careers in engineering. Students graduating from MIT with a bachelors degree in engineering receive substantially higher salaries than science graduates with doctorates. However, in the 1960s, when government support of science was at a peak, many students were drawn into scientific careers by the exciting opportunities to participate in the exploration of the universe and the making of discoveries. Since the decline of scientific support, however, MIT is producting more engineers and fewer scientists. MIT is not atypical in this respect. In addition to receiving higher salaries after fewer years of school, engineering students find it is much easier to arrange term-time and summer employment. MIT has several industrial liaison programs to help engineering students obtain summer jobs. Although MIT also has an undergraduate research program for science and engineering students, it is unfortunately becoming increasingly difficult to arrange projects in the sciences, specifically space science, because of a lack of government support for such research. If this trend continues, more students will turn from science to engineering, and this in turn will decrease the supply of qualified scientists and science educators in the future.

From discussions with my fellow students and with researchers and faculty at MIT, I believe that the problem of inadequate support of basic science is universally felt in the space science community.

It is often suggested that private industry could fill the research gap caused by decreasing government support. There are two major problems with this contention. Private industry must be profit conscious. Thus, corporations do not spend heavily in scientific projects that promise little or no immediate return on the investment. Science supported by private industry must be done primarily for short term profit, not for the sake of advancing knowledge. Monetary profit has never been the motive behind important fundamental advances in science. This does not mean that privately supported science is bad, rather it is very good, but it should be a supplement to science that is supported publicly.

One area of government supported research and development which is sharply increasing is that sponsored by the Department of Defense. This also does not solve the problem of maintaining a strong national program of basic science. Department of Defense research has a specific goal—producing for the military. Though some of the DOD research and development actually does profit basic science by a kind of technological trickle-down effect, its strictly goal-oriented nature severely limits the benefits to basic science. Also many students find DOD sponsored research in conflict with their moral and philosophical views. Thus, while DOD research does have certain scientific value, it does not fill the gap left by decreasing space science funding.

It is important to point out that a large NASA budget does not necessarily imply a large space science budget. The billions of dollars spent on the Space Shuttle have had little benefit for space science so far. Of course, the Shuttle will carry the European Space Agency's Space Lab and the Space Telescope into orbit. However, just as the Shuttle becomes operational, the U.S. space science program is on the decline. In conversations I've had with several members of the NRC and NASA, nearly everyone has referred to the shuttle as a "sponge" drawing funds away from scientific endeavors. The point is not that the Shuttle itself is bad, but that it is only one important component of a healthy space program.

I would also like to stress that the magnitude of the NASA budget for physics and astronomy is also not an indication of the support for basic research in space science. The proposed budget for physics and astronomy for fiscal year 1983 is dominated by industry-based efforts for space mission developments with very little support for basic space science. It is extremely important not to confuse the concept of research and development with that of fundamental research.

The problem exists, but how does it harm society? Why is space science necessary? I believe this is the most important issue in these heraings. Thus, I would like to highlight the folowing responses to these questions.

The United States is in a period of economic trouble. President Reagan has made economic recovery one of his top priorities. For him this means balancing the budget and cutting programs. Since space science research appears to have very little positive impact on society, it naturally becomes a prime candidate for budget cuts. Money is spent and knowledge is gained. However, it is difficult to see how this knowledge benefits society. I have spent the last year and a half helping a research scientist map the soft x-ray background of the sky as measured by SAS-3 (a NASA funded project). When I tell taxpaying citizens back at home about this they respond with a definite "So what?" They would much rather see tax breaks, a lower prime rate, reduced crime, and other such social changes.

Perhaps the best way to illustrate to you the reasons why space science is important to America is to explain why science is important to myself and other science students. A scientific education is very expensive. Four years of undergraduate work and three to six years of graduate study, often at an expensive private institution, costs a very large sum of money. As I mentioned, the job opportunities for a Ph.D. in astrophysics don't compare to the opportunities for an engineer with a bachelors degree. Students like myself are accumulating sizable personal debts with little hope of large earnings in the future because we feel that science is important and exciting. It is important on a level that cannot be measured in monetary terms. To question and ultimately to try to explain the unknown is a basic attribute of human nature. To some people the inherent drive to explain is greater that the instinct for financial security. Certainly, most of the scientists who make it through graduate school could have been successful in engineering school. I believe that everyone has a bit of this scientific curiosity within them. Many of the same people who question the social worth of the research I am doing are nonethless amazed at what science can explain. By failing to support space science and the other basic sciences adequately we are creating scientific stagnation in our country at a time when scientific advances are particularly important.

I believe science is important simply because it increases the knowledge held by mankind. Curiosity about the unknown is a trait of humans that should never be suppressed. However, this does not imply that science cannot be justified on the basis of practical and social benefits. In fact, the social advantages of science are widespread. Initially, scientific research breeds intellectual activity. A society needs scientists just as it needs engineers, politicians, doctors, and assembly line workers. Without scientists, society would suffer—perhaps not immediately, but harm would occur.

The most tangible societal benefits of science are the so-called spin-off technologies. Scientists do not always know what they will find in their investigations. This makes basic research difficult to justify in strictly monetary terms beforehand. However, much of today's technology emerged from scientific work that initially seemed unrelated to it. The examples are virtually endless. During the 1800s basic research was begun in the field of electricity and magnetism. By the latter half of that century James Clerk Maxwell put the ideas and experimental results of many scientists together and published what came to be known as Maxwell's Equations. The applications of this theory followed shortly thereafter and have been important in the development of today's industrial society. In fact, most of our current technology would be impossible without the theory of electricity and magnetism.

The experimental and theoretical work in science may now seem economically unproductive to some, but I feel that the scientific research done today will have direct and beneficial impact on tomorrow's society.

I have tried to show you why I believe that basic research is beneficial and worthwhile. I would now like to speak specifically on space science. Though research in space is very new, scientific research pertaining to space is one of the oldest forms of science. Mankind has stared into the cosmos with wonder and curiosity since the beginning of recorded history. Current research includes many fields of science; satellites are used as astronomical observatories, probes are sent to our neighboring planets, and the Earth is studied from a new perspective. Moving science into space has created endless new opportunities to explore, measure, and understand new and old phenomena.

To date, America has had the greatest number of and the highest quality scientific projects in space. But now the U.S. has no expedition planned to Halley's Comet in 1986 while Japan, the European countries, and Russia plan to take advantage of this rare opportunity to study a coment. This is particularly disturbing since America could have produced a probe of superior quality. Other examples: Russia just landed a probe on Venus and Japan has the world's only operational X-ray astronomy satellite. Particularly shocking is the cancellation of the International Solar Polar Mission to explore the unknown regions over the Sun. The U.S. has backed out of most of its responsibility of this project with the ESA. We will still launch the ESA's probe, but the U.S. will not build the planned duplicate probe and the entire project will suffer. Just as other nations are implementing strong space science programs, it seems that now is the worst time to slow our program.

Finally, I would like to underscore my belief—a belief widely held in the scientific community—that space science (in fact, all science) is justifiable solely on the basis of advancing knowledge. Perhaps the most common argument against an active space program is the one that emphasizes the need to solve immediate problems on Earth first. But space science, I would argue, does address immediate problems; it provides jobs, increases productivity, and produces spin-off technologies. Yet, I do not want to mislead you. I am not pursuing a scientific career because I believe that my work will solve immediate social problems. I do not believe that the primary reason many scientists investigate the unknown is to feed the poor or lower the crime rate. Certainly, many scientists are also concerned about such social problems—I know that I am. However, science is important to me because I have a natural desire to discover and to increase our knowledge of the universe. Moreover, at a time when productivity and national morale are low, I believe that the instinct for discovery and the quest for knowledge can contribute positively and should be publicly supported.

[The following information was subsequently received for the record:]

CAMBRIDGE, MASS., *May* 19, 1982.

Senator HARRISON SCHMITT,
Russell Senate Office Building,
Washington, D.C.

DEAR SENATOR SCHMITT: I received your letter and questions regarding my testimony before the Subcommittee on Science, Technology, and Space on March 30, 1982. My responses are enclosed.

I would like to thank you for this opportunity. I certainly hope the subcommittee learned as much as I did. Writing my testimony forced me to ponder some difficult issues. The questions you asked resulted in many frustrating and rewarding hours of struggling with complex problems that I will surely face again.

One of your questions asked me if my opinions were representative of my peers. Just a couple of days after I received the questions and had outlines written I brought up these issues in a conversation that was taking place in the lounge of my dormitory. I could not believe the interest in these topics. I gave up at about 6:00 a.m., but several others continued discussing and filled me in the next day. This prompted me to distribute drafts of my responses to a cross section of my friends. I went to great lengths to make sure that all types of people were represented. I discussed the issues with science and engineering majors, law students, managerial and economics students, students in the various Reserve Officer Training Programs, and professors. I also tried to get a good mix of men and women as well as students from different backgrounds with varying financial situations. The opinions expressed are entirely my own (except where noted), but these discussions certainly affected my responses.

My academic term ended this morning. After a two week vacation in beautiful Oregon I will be back at MIT for a summer job at the Center for Space Research. I should have significantly more free time than I have had recently. If you would like any more opinions, comments, or help of any nature feel free to contact me. Thank you once again.

Sincerely,

JOSEPH R. MINATO.

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

1. How might groups of students like yourself play a more important role in the political process as it affects funding of scientific programs? What would you recommend that your professors do to play a more active role? Do you feel that political action by scientists is consistent with their attempts to remain objective in the pursuit of their research goals?

To maximize our effectiveness in supporting science, students will need to do at least three things. Initially, it is very important to be well informed. This includes being knowledgeable about the history of funding for scientific programs, benefits of past projects, specific immediate problems limiting science, and long term difficulties resulting from inadequate funding. However, it is also important for students to be aware of the political process involved in conveying our message to politicians.

Secondly, we must actively work to influence public policy. Ideally, this means well planned visits to Washington, D.C. including meetings with important policy makers. This is not always possible since students can rarely afford the time or money for such visits. Alternatives are phone call campaigns that occur just before important votes and persistent letter writing. The underlying goal should be to explain our position and reasoning to Congress and the Administration so that they will be well informed and will do what is best for both the immediate and distant future.

Finally, concerned students must inform and arouse fellow classmates. From my experiences, I am convinced that most students have viewpoints similar to mine on the issue of scientific funding, but few are excited enough to make the time commitment necessary to be effective. Since students are kept sufficiently busy during the academic year, political efforts must take place on weekends or during vacations. When most students learn the facts regarding the support of science, they are appalled and proceed to express their feelings.

The role of professors should be analogous to that of students. Although they have the necessary scientific background, they must become aware of the political process. The most important thing professors can do is to actually get excited and lobby by visiting Washington, D.C., making phone calls, and writing letters. It is reasonable to assume that established scientists have more political power than students. Because of this, it is extremely important for them to become involved in the political support of science. Active professors should also encourage their colleagues to take a serious interest in the politics of science.

Overall, professors and students should work together to ensure sufficient funding for scientific projects to keep American science at the forefront and to build for a strong scientific future.

Political action by scientists can be, but is not necessarily, consistent with objectivity in science. A scientist should be concerned with the scientific community as a whole, not just with his field or his particular projects. It is natural to support most vigorously one's own project. This is fine as long as the scientist's underlying goal is the pursuit of knowledge for the benefit of humankind.

2. Do you feel that scientists have become distant from the political process?

Because most science is publicly supported, scientists are necessarily attached to the political process. In this sense, they are not "distant" from politics; however, as a whole, scientists are not sufficiently informed or active politically.

Scientists must not assume that research grants will automatically be available. It is important that they are politically experienced so they can justify research and increase funding for scientific projects. Most importantly, scientists must actively pursue a healthy scientific future to a greater extent than they have done in the recent past.

3. What are your views on whether this country's military mission should include the active use of space for both defensive and offensive purpose? Is your opinion representative of your peers?

It is my belief that weapons in space should be absolutely forbidden with no exceptions. This new frontier has enormous potential to make life better for the human race; yet incorrect use of the technology related to this frontier has the potential to destroy us. I would protest weapons in space even if it meant a possible decrease in space science.

The U.S. is already using space for a defensive purpose, namely surveillance. Ideally, I am opposed to this; however, because other nations have demonstrated that they cannot always be trusted and because surveillance satellites already exist, I am willing to accept the use of space for some defensive objectives. I must stress that I am using "defense" in a very strict sense that excludes any form of weaponry. There is no such thing as a defensive weapon.

I have spoken to many students on this and similar issues. Only a very small minority felt that the U.S. should put weapons in space. The opinions regarding the use of space for solely defensive purposes varied, but the bottom line was almost always no weapons in space. Arguments suggesting that the Soviets are militarily superior and the U.S. must catch-up are rejected as fallacious by nearly all of my acquaintences (including professsors). The arms control movement is very strong among students and at universities in general. We feel that prohibiting weapons in space is necessary, but not sufficient for a safe future.

Many science students, including myself, believe not only that space should be kept free of weapons, but further that funds should be diverted from wasteful military projects to cause that work toward the benefit of humankind, such as the civilian space program. In a report made public May 2, 1982 the General Accounting Office showed that about one-fourth ($1.5 billion) of the NASA budget is used to support military goals. Dr. Frank Press, President of the National Academy of Sciences, has commented that about $600 million is needed to bring the federal budget for all basic scientific research to a sufficient level. Clearly, only a fraction of the NASA budget that is military related would need to be diverted to maintain a vigorous and healthy space science program.

4. Do you feel that the presence of such defense supported research establishments such as Lincoln Labs is resented by university students?

This question gets to the center of the issue regarding government support of universities. Students have a natural tendency to support any form of aid given to themselves or the universities they attend. However, many of these same students object strongly to the military policy of the U.S. Most students find this conflict very difficult to resolve. The most common solution I hear is one suggesting that work on a Department of Defense grant is morally acceptable as long as it is impossible to see specific military applications of one's work. For example, the MIT Artificial Intelligence Laboratory receives most of its funding from the Advanced Research Project Agency of the DOD. It is also a very popular employer of students. Most of my acquaintances who work at the AI Lab say they would prefer working on a civilian grant, but explain how excellent that Lab's facilities and funding are, and contend that a job at the Lab is very hard to reject even though they have reservations about supporting the military.

Lincoln Labs, however, has a significantly different image. Many students are not aware that it is funded by the DOD. Those MIT students that are aware of this support think of Lincoln Labs as a place that produces for the military much more directly than the AI Lab or other centers that receive funding from the military. I wouldn't say that the DOD support of Lincoln Labs is "resented" by all or most students, but certainly a noticeable fraction are disturbed by this support.

In the late 1960s and early 1970s, student opposition to Draper (Instrumentation) Labs grew to such a level that protests and even small riots became commonplace at MIT. By the spring of 1970, the student unrest was so widespread that the last three weeks of classes and final exams were cancelled, and the students were forced to leave campus. Since the only important difference in 1970 between Draper and Lincoln Labs was that Draper was on campus and Lincoln was several miles away, it is clear that this military work was strongly resented. Since then, students have settled down significantly; however, one of my instructors commented last week that she feels the beginning of the same air of unrest that was present in the 60s.

In summary, Lincoln Labs has been somewhat insulated from student protests due to its location. However, many students are unhappy about this affiliation of the DOD with MIT.

5. What is the interest among college students in the astronaut corps? Do you think that NASA provides sufficient information on the subject? Is the impression among your friends that with the success of the Space Shuttle more opportunities will exist to go into space? Would you like to go into space?

The astronaut corps is not well known among students at MIT. Those that are aware seem to think it sounds interesting. Certainly, space travel is an adventure that many find exciting. It is clear to me that NASA does not succeed in spreading enough information regarding this topic.

Many students find the status of the U.S. space program disappointing. I cannot recall speaking to a single student who is even modestly satisfied with the direction of our space program. Not everyone agrees what the direction should be. Many believe that we should industrialize and inhabit space while others, like myself, believe that fundamental science should get first priority. Most are very dissatisfied with the Space Shuttle. Few feel that the Shuttle will offer them significant opportunities to go into space.

Personally, I would find space travel very exciting. However, I believe we must undertake projects that yield the most long term benefits for the space program, the U.S., and humanity. I am not convinced that large-scale space travel or colonization should be focussed on as a goal for the immediate future. In fact, I feel this would financially preclude more important scientific projects.

Senator GORTON. At this point, before the third and fourth witnesses and panels, the subcommittee will be in recess for a few moments. Unfortunately, I must go to a markup on the Clean Air Act and Senator Heflin is due imminently to carry on the second half of the hearing. But we will now have a brief recess.

[Brief recess.]

Senator HEFLIN. If we may, we will call the panel of Drs. Hinners, Wheelon, White, Young, and Townsend, if they will come at this time. Some of you may know we have problems in that the Space Shuttle did not land on time, and Senator Schmitt, the chairman of the subcommittee, is unable to be here. They are drawing from the bottom of the barrel with me as junior Democrat to preside here. And I, as all junior Democrats, have 15 things to do at the same time.

So basically, rather than having postponed the hearing, since word could not have gotten to everyone, we thought we would go ahead and let you put your statements in the record. If you do not have a written statement, you may file it later.

So with that in mind, we are going to have to keep this short. But I promise you that staff will read very diligently your written statements, and they will digest it, summarize it to the various members of the subcommittee, and it will not be for naught.

I have found that oral in addition to written statements add very little to the overall situation. So you would get about 2 minutes, we would start with Dr. Wheelon, if you would start, sir.

STATEMENT OF ALBERT WHEELON, VICE PRESIDENT AND GROUP EXECUTIVE, HUGHES AIRCRAFT CO.

Mr. **Wheelon**. Yes, sir. I do have a written statement which I would like to submit for the record. I will pick up a few major points here in the 2 minutes you have kindly allocated to me.

The science and applications program has been an exciting one. We are just rounding 25 years, and I think the program has been an important chapter in our country's history. It has done an awful lot of important things for rather reasonable money.

The country's space program is far more than just the NASA program, of course, and I think we should look at the NASA program in that broader perspective and context. We have a vitally important, widely based military program. We also have an increasingly important civilian program, based on commercial communications satellites. We have a big space program of which NASA is an important part. And we have a healthy industry.

However, I think the NASA science and applications program is in trouble. This trouble is the result of vacillation in the decision-making process, mission delays, budget reductions, and the effect of the Shuttle getting first priority at every turn in the road. As important as the Shuttle is to the country, it seems to me that the Shuttle has had a bad effect on the science and applications program. We have postponed or failed to do many things in order to accommodate the financial needs of the Space Shuttle. That is history, and is part of our background.

The point in raising this today, Senator, is to think about the future. If we go into a space platform program we need to make sure that such a program does not act as a glacier for another decade clearing a wide swath through the science and applications program.

I think the physics and astronomy program is in good shape. It has been generously funded. It is largely out of the public eye. It is a scientific program for and by scientists. It is an area of substantial international cooperation. And as your House colleagues heard in our last presentation, it takes about half of the total space science and applications budget.

The planetary program, by contrast, is about one-third the size of the physics and astronomy program. It runs about $150 million a year. It has been a rapidly declining program. If you count just unmanned missions—and that is the cheapest way to do planetary exploration—there were 38 lunar and planetary missions in the 1960's. There were 14 in the 1970's. There is going to be just one in the 1980's. I think the statistics speak eloquently.

I would like to use part of my 2 minutes to say that I believe it is within our means to reverse the trend in the planetary program. I think it would be exhilarating if President Reagan were to announce that:

> The United States will complete a systematic reconnaissance of the planets and our solar system before the year 2000 and that we will share the results of that exploration with the peoples of this planet.

I believe such a reconnaissance could be carried out within a reasonable budget; on the order of $200 million per year. This is not too much above where we are now. This program should be established and then not changed by agreement between the Congress and the Executive for the next two decades. If we do so, I think we can complete the program in that time. I think the country would be proud of our achievement. And I think we would do good science for a very modest investment.

What is killing us now is the indecision and the constant change of direction. It is a stop-start, on-again-off-again kind of activity. That is what is doing us in, rather than the level of funding.

In the area of communications, NASA took an important early leadership role in showing that geostationary satellites could be done early and well. Syncom followed by the ATS program has resulted in an extraordinarily healthy American communications satellite industry. American firms have built or are building 81 C-band satellites for about nine different private companies. And that is not Federal money; it is private money, private technology.

The newer band is K-band. There are 16 such satellites that either have been launched or are being built for 5 separate customers. Some of my colleagues will talk about the new frequency bands that have not yet been developed, so I will leave that alone.

Direct broadcast is an area where the country is not in very good shape. The Europeans have taken the lead there. And as you may know, there are before the Federal Communications Commission today eight applications for permission to establish and operate direct broadcast satellites over the United States. And yet I fea that we do not, as a country, have the technology that is required for those systems to operate for 7 or more years.

Regarding weather observation: My colleagues will talk about that. I would like to raise one point, however. As you know, there are low- and high-altitude systems. The high-altitude geosynchronous system includes five orbital positions around the world. By common agreement under the World Meteorological Organization, two of those are to be filled by U.S. satellites, one by a Japanese satellite, one by a European satellite, one by Russian satellite.

The two U.S. satellites have been in place since the mid-1970's. The European satellite has been there some of the time. They have had on-orbit failures. The Japanese satellite is in place. The Russian satellite has never been established. I wonder if it is really in our national interest to rely on satellites that are not there or that are under foreign control. If this is really an important part of our understanding of the world's weather, why don't we establish a complete system under our own control?

I think my time has run out, so I will defer to my written statement for the rest of my points. Thank you very much indeed.

Senator **Heflin**. Thank you.

[The statement follows:]

STATEMENT OF DR. ALBERT D. WHEELON, SENIOR VICE PRESIDENT AND GROUP PRESIDENT, HUGHES AIRCRAFT CO.

INTRODUCTION

Mr. Chairman and members of the subcommittee, it is a pleasure to be invited here today to comment on NASA's Space Science and Applications Program.

This is NASA's 25th year. Those 25 years represent a success story and a significant chapter in our country's history. In this period, we have passed from an early fascination with space to a national dependence on information derived from satellites. Our space science program has revolutionized man's understanding of the earth, our environment, our solar system, and the universe. Space has also established America as a technological and scientific world leader. The cost for space science and applications programs has been very small: about $9 per year per taxpayer. The return has been high.

Space has become much more than just the NASA program. The defense space program is a major element of our national activity. Moreover, the private sector is heavily engaged in developing, financing and operating communications satellite systems. Tomorrow, the private sector may also be involved in weather, land, and ocean remote sensing systems.

The current NASA space science and applications program is characterized by budget reductions, mission delays, and planning vacillation. This situation has been driven and compounded by Space Shuttle cost growth and schedule slips during a period of constant NASA budgets. The end result is that an important national program has been badly wounded. We must be careful that future major thrusts, like the space platform, do not create similar conditions for the next decade of science and applications programs.

My remarks will express both concern and optimism. Concern because of the difficult circumstances under which our space science and applications program has been operating—and may continue to operate. Optimism because there are solutions which could reestablish the pace and progress of a vigorous program. Such a solution will require a national commitment, dedicated planning, and consistent execution of an agreed upon course of action by all concerned.

I would like now to address the principle major areas in NASA's space science and applications program—and technology in general.

PHYSICS AND ASTRONOMY

The physics and astronomy program continues to revolutionize our understanding of the universe. In combination with the planetary program, it is revealing our solar system to us. It has produced major accomplishments with programs like HEAO and OSO. The small Explorer class spacecraft have produced excellent science return at a modest cost. The Large Space Telescope and the Gamma Ray Observatory are now in development and should produce significant science. For the future, OPEN (Origin of Plasmas in Earth's Neighborhood), and SIRTF (Shuttle Infrared Telescope Facility), among others, are well worth doing.

Funding for this program has been constant over the past ten years. This funding has been generous, averaging about 6 percent of the NASA budget. $472 million will be spent on physics and astronomy in 1983. This is approximately half of the entire space science and applications budget. It is more than three times the expenditures on planetary exploration.

It is a purely scientific program. The public is almost totally unaware of its existence. It is an area of substantial international cooperation. The Europeans are active in their own right with such missions, and Japan is beginning to plan their own.

PLANETARY

In two decades, we have visted the moon, Mercury, Venus, Mars, Jupiter and Saturn with unmanned spacecraft. We will soon encounter Uranus and Neptune. This close-up exploration has greatly increased our knowledge of these planets and the solar system. Our willingness to share results with the world has been a demonstration of our free and open society. The planetary program has been a symbol of our national strength. It is a right source of pride to our people.

The direct cost of the planetary program has averaged about $187 million a year over the last five years. This represents about 3½ percent of NASA's budget. Planetary exploration will account for just over 2 percent of the NASA budget in 1983.

The average cost per taxpayer has been about $3 per year, equivalent to the cost of a neighborhood movie once a year.

If we focus only on unmanned missions, there were 38 lunar and planetary launches in the 1960's, and 14 in the 1970's. There is just one approved mission for the 1980's! No new planetary program has been initated in half a decade. When adjusted for inflation, the proposed planetary budget for fiscal year 1983 is one-fifth the program of ten years ago and two-thirds the expenditures of five years ago. Vacillation and uncertainty of purpose have compounded this funding decline. The problem has been compounded by unwise decisions made in regard to launch vehicles required for planetary missions.

A healthy and vigorous planetary program can be established even with NASA's current budget limitations. There are many missions with modest costs that can sustain the science, adventure and prestige of this effort. Hughes Aircraft Company has proposed several such missions. Noel Hinners and the Solar System Exploration Committee (SSEC) have defined more.

The common theme of thest missions is the extensive use of existing designs and equipment developed on other programs. The essential element is scaled-back, but meaningful, science objectives.

It would be exhilarating if President Reagan were to announce:

"The United States will complete a systematic reconnaissance of the planets in our solar system before the year 2000, and will share the results of this exploration with all the people of this planet."

A stable planetary program budget consistent with this objective could then be established. With clear direction, NASA and the science community could proceed in a sure-footed manner to fulfill that mission. To a stable program, industry could contribute its technology developed on DoD and commercial programs. The nation could continue to enjoy the science and adventure of exploration.

COMMUNICATIONS

NASA and DoD sponsorship of Syncom in the early sixties proved decisively that synchronous communication satellites were feasible much earlier than had been assumed. NASA went on to sponsor the ATS program which demonstrated the utility of synchronous satellites for additional services, such as mobile communication and weather forecasting. However, NASA withdrew from this activity in 1974. The recurring question since then has been: "Was this wise?"

The NASA early initiative in communication satellites has led to a healthy and broadly based industrial activity. American firms have built or are building 81 C-band communication satellites for 9 private customers. They have produced or are producing 16 K-band satellites for 5 privately funded customers. The question is: "What remains to be done?"

Recently NASA chose to enter the communications satellite field in the 30/20 GHz band. The question is: Who is planning to use this frequency band? Unfortunately, there is no commercial customer who plans to use 30/20 GHz for broadband service. Experiments have demonstrated undesirable propagation characteristics in rain and snow. However, the military is planning a narrow band system operating at 44 and 20 GHz. They are beginning the important development of the required 20 GHz TWTs, solid-state devices, TDMA switches, and so on. This technology is now being funded where it will be employed—in DOD. It will be available later for commercial applications. At a time of economic crisis, a 20/30 GHz demonstration system for NASA seems to fall in the category of desirable rather than essential.

Direct broadcast satellites represent an emerging technology. Economic viability will revolve mainly around the development of long-life high power traveling wave tubes providing several hundred watts. NASA developed such a tube in 1976. Since then, however, European rather than American firms have pursued this technology for their own use and export sale. Europe will probably win a significant share of the direct broadcast satellite business because of their investment.

WEATHER OBSERVATION

Another far reaching product of NASA programs has been the NOAA low-altitude and GOES geosynchronous altitude weather satellites. These spacecraft are currently procured by NASA for NOAA. NOAA assumes operational responsibility once final orbit is achieved. It was NASA sponsorship of the ATS and its spin scan camera which proved the concept of continuous global weather monitoring from geosynchronous altitude in 1967. The first operational geosynchronous Metsat, was launched by NASA in 1974. The first Tiros low-altitude weather satellite was launched by NASA in 1960. These were the forerunners of today's GOES, NOAA, and DMSP operating systems.

Because of the operational success of these systems, there is an understandable resistance to change. Since the first Visible and Infrared Spin Scan Radiometer (VISSR) was introduced in 1974, there has been only one improvement in this basic instrument. That was the addition of an atmospheric sounding capability in 1981. Other system improvements are feasible and desirable. These include stereo coverage, higher resolution visible and IR imaging, all-weather microwave imaging and sounding and high resolution storm tracking. It once was NASA's role to develop and verify these improvements. This type of work was deleted from the NASA budget in fiscal year 1982 and the responsibility given to NOAA. NOAA has neither the resources nor the technical expertise to develop these improvements. It is desirable for NASA to again assume this much needed function.

The two U.S. GOES spacecraft currently in orbit are one part of the World Meteorological Organization (WMO) cooperative weather system. This system includes five geosynchronous orbital slots. Two are assigned to the United States and one each to Japan, Europe, and the USSR. After more than a decade, the USSR has yet to provide its promised coverage. Europe's Meteosat has been operational only some of the time. Gaps in world-wide coverage therefore exist. The importance of world-wide weather monitoring suggests that consideration be given to filling these gaps with United States spacecraft. Weather data has always been provided as a governmental service even though some of the analysis and forecasting using this data has been done in the private sector.

EARTH OBSERVATION

The keystone of this program is the Landsat series of spacecraft. The first Landsat was launched in 1972. It carried an RBV (Return Beam Vidicon) and MSS (Multispectral Scanner). The MSS quickly became—and has remained—the primary sensor for civil applications. In July of this year, the first of the second generation Landsats will be launched incorporating a TM (Thematic Mapper) with improved spatial and spectral resolution.

The future of this program is in substantial doubt. The issue of private versus government operation has confused planning for future Landsat coverage. Data continuity is now seriously threatened. Technology development has all but stopped areas such as MLAs, stereo systems, and synthetic aperture radars. Outside the United States, a French system is planned for launch in 1984. A Japanese satellite is planned for launch in 1987. These programs represent a challenge to U.S. leadership in remote sensing, and poses the potential threat of our dependence on other countries for valuable economic information. In contrast to weather data which is in the public sector, resource data has been a mixture between the private sector and the public sector. Oil, mineral, and underground water exploration has usually been performed in the private sector; crop forecasting has been in the public sector.

An early resolution of the private versus government ownership issue for Landsat is required. This decision must recognize that government agencies will always be the principle users of this data. The government will necessarily represent the major market for any private enterprise assuming ownership and operation of Landsat. If it is determined that resource observation is best performed within the government, other options exist. One possibility is to fly Landsat instruments on DOD host vehicles. In general, orbit parameters, data rates, and other operational requirements of these missions seem compatible.

An emerging application of earth observation from space is in the field of oceanography. Results from the Seasat experiment show great promise. Development of active and passive microwave sensing techniques have been inhibited by budget limitations and problems with interagency agreements. This is another area where a more vigorous space applications program could benefit the nation.

TECHNOLOGY DEVELOPMENT AND INTERNATIONAL COMPETITION

Both the DOD and NASA programs support space technology in ways that are important to our entire space program. They do so directly and indirectly. The direct program is specifically identified in the budget. The NASA budget for this effort has been constant at about $110 million for the last few years. The DOD has a similar program at about an $80 million level. NASA's technology program could play a more relevant role in U.S. technology. In doing so, it should focus more on the long range development of materials, devices, and components that could benefit the nation's commercial as well as public space program in the 1990's. In this regard, close coordination with DOD's technology program is desirable. The two programs can serve the nation's growing space applications program in the same way the aeronautics program serves the aviation industry.

However, indirect support of American space technology provides the really important advantage to America. Because the overall U.S. space program is so vigorous and broad, our component and subsystem suppliers have a large market within which to develop their products. By doing so, they can bring unit prices down. Neither Europe nor Japan has such a base. They must subsidize both their development and production to make their products competitive. The present free market system is working to American advantage so long as our technology is vigorous and our total space program large.

CONCLUSION

Mr. Chairman, there is cause for concern and cause for optimism today. Our space program is basically healthy. It is also in disarray. Now that the Shuttle is flying, it is time to redirect and reinvigorate the vital areas of science and applications. The opportunities and benefits are plentiful. This can be accomplished within a modest constant budget.

Senator HEFLIN. All right, Dr. Hinners, we will be glad to hear from you.

STATEMENT OF DR. NOEL HINNERS, DIRECTOR, NATIONAL AIR AND SPACE MUSEUM

Dr. HINNERS. Thank you, Mr. Chairman. I would like to touch on two topics in the short amount of time. One, the perception of the public support for the aerospace program, as I see it now in my role as Director of the National Air and Space Museum. We are the most popular museum on the Mall and, I believe, in the world, with over 50 million visitors since we opened in 1976.

In talking with these individuals, I see what it is the U.S. public obtains from the U.S. space program. As individuals, the people are drawn by a combination of reasons and experience, a variety of reactions in the museum, including a desire to learn, an appreciation of the practical benefits, awe of the technology, some nostalgia for exciting times past, and reverence for individuals who overcame physical and mental barriers.

The most common thread which runs through our visitors, especially the children and the senior citizens, is one of inspiration. They see what the United States has accomplished with the science and technology, and in a time when so much else around us is negative, the air and space activities of the country represent a very positive influence on our mental well-being.

The public support rarely aggregates itself into a visible voting bloc, but I am convinced by what I see of the visitors that the support is there, in aggregate, for a very vigorous U.S. space program.

I would next like to comment on my role as the Chairman of NASA's Solar System Exploration Committee. NASA formed the committee 2 years ago to try to get out of the problem of diminishing solar system exploration. Our charge was to look at the reasons for the problem, which in large part were budgetary, and to come up with an implementation plan for the future which will get us back on track for planetary exploration.

We are in the midst of our activity now and expect to finish up the first phase by September of this year. Working with NASA this summer, we hope to influence the 1984 budget formulation.

But there are a few points I would like to bring out to the subcommittee at this point that I see as problems that are beyond our control, to some degree.

No. 1 is that the concept of low-cost planetary missions. While we think it is credible and believable for some certain number, is not the complete answer to reviving the U.S. planetary program. Missions of the Viking, the Voyager, and Galileo class are still going to be necessary to do the right job of planetary exploration through the next several decades.

In coming up with a viable program, we see that starting in the early 1990's we are highly dependent on the availability of new high-energy launch stages and low-thrust propulsion. The planetary program has never been able to drive that requirement on its own, and yet we constantly are told, well, it will come when the demand aggregates. Getting that demand to aggregate in time to apply it to a planetary mission has been a very frustrating wait, and is one I think needs to be addressed by the committee.

Another problem which we face in instituting the revived planetary program is to get out of the syndrome of what I call the new-start numbers game. The key to our approach, lower cost planetary exploration, is frankly in biting off smaller chunks of science per mission. That is the quickest way to reduce the cost. That means stretching things out. But it also results in a plan which appears to have more activity. There are more launches to accomplish the same amount of science.

In an atmosphere where the progress of a program is counted or measured primarily by the activity as represented by numbers of missions, this is a bad approach. I think we need to work with NASA, OMB, and the Congress to get away from measuring progress in science by the number of launches and try to let the amount and kind of data that is coming back show us where in aggregate the program is going.

A point I would like to make again is that of launch vehicles. I mentioned it just a minute ago, but I would like to reemphasize the requirement for the 1990's: that there be developed new launch technology for planetary missions. Part of that helps to reduce the trip time which with the outer planets gets to be 4, 5, or 6 years, incurring a high cost during that trip time.

Last, the result of NASA in the 1983 budget in reducing the planetary advanced technology development and research and analysis is catastrophic. The ability to structure a revived planetary program depends upon advanced instrument development and on doing the right job of analyzing the data in hand and coming back from operating spacecraft.

Without getting that baseline program back on track, it is doubtful to me whether or not the Solar System Exploration Committee can come up with a good long-term implementation plan. Thank you.

[The statement follows:]

STATEMENT OF DR. NOEL W. HINNERS, DIRECTOR, NATIONAL AIR AND SPACE MUSEUM, SMITHSONIAN INSTITUTION

Mr. Chairman and Members of the Committee, I thank you for the opportunity today to comment on the state of the Nation's space science program with special regard to the impact of recent budgetary constraints. I'd like to address three areas which, while disparate on the surface, integrate to form a major part of my personal view of the space science program. I'll first present my judgement of the public perception of the U.S. Space Program, next give a status report on the efforts of the Solar System Exploration Committee to help revive planetary exploration, and finish with commentary on the need for and health of the baseline non-flight programs.

Three years ago I left my NASA position of Associate Administrator for Space Science to become Director of the Smithsonian's National Air and Space Museum. A prime reason for assuming this new responsibility was to enable me obtain a different perspective on the U.S. Space Program, to better comprehend its significance to the public, to consider some of the international aspects and to assess the involvement of the scientific community.

At the Museum I have indeed had the opportunity and environment in which to develop views on those topics. In sharing them with you, I hope that you might find them useful as you wrestle with the NASA budget and the underlying philosophy of the U.S. Space Program.

The public attendance at the Air and Space Museum is among the largest of any museum in the world, over 50 million in a little over 5 years. As individuals, people are drawn by a combination of reasons and experience a variety of reactions, including a desire to learn, appreciation of the practical benefits, awe of the technology, nostalgia for exciting times past, and reverence for individuals who overcame mental and physical barriers. The most common thread which runs through our visitors, especially the youth, but also our Senior Citizen, is that they are inspired by the feats of individual and colletive accomplishments as now represented by artifacts. Looking beyond the tedium and sometimes despair of everyday survival, they aspire for a future for our country and for themselves which includes the adventure and intellectual challenge of exploration of and beyond the planet earth. Air and space pre-eminence is identified with America and I sincerely believe that the collective public interest represents broad-based support for a vigorous U.S. Space Program. I also believe that my view is a more accurate assessment of citizen interest in and the value of space exploration than indicated by the simplistic and obviously flawed poll taken March 11–15 by the New York Times/CBS News Poll. The question posed "Are you excited when you see a space launch or don't you care all that much about it?" Such a vacuous question is guaranteed to elicit an uninformed and uninformative answer (for what it's worth, 51 percent were excited).

The U.S. civil Space Program is recognized and respected worldwide. To the 15 percent or so of our adult Museum visitors who are foreign, it represents a positive achievement of science and technology, one which the U.S. shares openly with the world, in distinct and obvious contrast to the Soviet Union. Transcending the admiration is a degree of envy and oft-expressed desire to share, emulate and maybe surpass our accomplishments. One sees an increasing spirit of competition, especially in the European countries and Japan. I believe that is in the the best interests of the U.S. and the world science community to strive to reduce the competitive nature and foster the cooperative. To the degree that elements of the Space Shuttle and the Applications Programs become intertwined with the military programs, with a resultant secret component, and to the degree that commercial prospects become real, international cooperation and the political benefits that now accrue to the U.S. will become diminished. In that context, the space science program becomes unique and provides the best prospects for a continuing source of open, beneficial cooperation.

The very public accomplishments of the U.S. Space Program, such as Voyager, are the end result of decade-long commitments to planning, implementation and data analysis. That commitment involves major segments of the science community, a commitment coming under increasing scrutiny as the future becomes less certain. The prospects for a viable future tend to be measured in terms of new data opportunities. The nation's space scientists are well aware of both the broad national fiscal problems and those unique to NASA and for several years have accepted the necessity for no new starts. I believe that the long-term good health of the U.S. civil Space Program now begs a commitment to new science, applications and technology missions and thus to the future of exploration. Such commitments would be a very visible sign of the basic vigor and determination of our society.

A particular sense of urgency for new commitments arises in part because of the dearth of recent mission initiations in planetary exploration. The Galileo Jupiter mission, started in 1978, is the last approved U.S. planetary mission. The paucity of recent new starts, caused largely by budgetary constraints, creates an inevitable hiatus in U.S. solar system exploration. To help rectify this situation, in 1980 NASA formed the Solar System Exploration Committee (SSEC) whose charter is to translate scientific strategy into a technically sound mission sequence for the 1980's and 1990's, and to make specific recommendations regarding the next mission initiation. Taking cognizance of past problems, the SSEC is developing an implementation strategy consisting of a mix of inner planet orbiters, atmospheric probes, and small body/outer planets spacecraft. Lower mission cost is a front-end objective, thus the strategy is characterized by extensive use of hardware inheritance, improved operations efficiency, increased modularity and reduced science expectation per mission. The rate of new starts and mission sequence is constrained by tentative budgets of $350M-$400M/year in Fiscal Year 1982 dollars and by launch vehicle availability and capability (there remains uncertainty on a high energy upper stage an low-thrust propulsion). The baseline strategy does not allow for Voyager or Viking class missions. Given the scientific importance of earth-returned samples of comets, asteroids and planetary surfaces (Mars and Venus), such missions are being considered but "below the line."

The SSEC effort is not yet finished. We are at the stage where we are convinced that there does exist a small number of lower cost, inner planetary orbital missions and that there are efficiencies to be gained by the development of a modified Mariner approach to the continued exploration of comets, asteroids and outer planets. The details of the approach are being developed by NASA Headquarters and Ames Research Center, the Jet Propulsion Laboratory, and industrial contractors. Working with NASA, the SSEC expects to influence the fiscal year 1984 budget formulation this summer and to write its report in September.

Without pre-empting the SSEC final conclusions, I would like to mention areas of concern. First, the concept and extent of lower cost planetary exploration, while credible, remains to be demonstrated. The tendency of some interested observers to embrace the concept prior to seeing the results of good studies leaves us a bit uneasy. Our rough guestimates at desirable costs per mission, iterated with the science strategy and what we believe to be a modest rate of return of new data, results in an implementation model building to annual budget levels of $350-400M in fiscal year 1982 dollars. This is higher than some of the non-SSEC numbers I've heard recently and reflects the fact that those other estimates considered only segments of the spacecraft portion of the budget and also neglected the base program whose level ought to be in the region of $100M.

A second concern is "new starts" in its simplest sense. Over the years there has been a tendency to measure rate of progress by the number of "new starts" allowed. To some extent that is indeed a measure of activity but becoming more important is the consideration of what each mission accomplishes. Part of the SSEC approach to lower cost is to simply bite off a smaller chunk of science per mission, to more highly focus science objectives and thus take longer to accomplish a given amount of science. One net result is an implementation plan with a lot more apparent activity because of more individual missions. Successful implementation of the SSEC approach demands that NASA, OMB and the Congress not count numbers of spacecraft as the prime measure of progress. This is a genuine mental hurdle.

A third major concern regarding SSEC activity is that by dint of our own groundrules Voyager, Viking, and Galileo class missions are not in the base plan. Yet, there are still a number of quality opportunities, including sample return from Mars and comets, which cannot be accomplished in the SSEC low cost mission mode. Such missions, as their precursors, involve a lot more than science—the exploration, high technology, and prestige. The SSEC, although accepting that larger missions are not in today's budget outlook, believes that they must not be ignored. The challenge is to devote some fraction of resources to keeping the concept not only alive but moving ahead to be ready for the eventual opportunities.

The last SSEC point I'll make here is about launch vehicles. Solar system exploration missions usually put the greatest demands on launch vehicle performance and capability. We are, however, in the totally frustrating position of not being able to justify the development of new capability on the merits of solar system exploration alone. And, as you know all too well, launch vehicle development takes longer than spacecraft development so ought to precede mission initiation. Therefore, the SSEC plan is being structured with the first several missions sized to IUS or other available launch stage capability. Missions envisioned for the 1990's, including most of those to comets, asteroids and the outer planets require a high energy upper stage and low thrust propulsion. We will work with NASA to help solve this dilemma, one route of which is an aggregation of requirements from different users.

The SSEC initiated its activity almost two years ago assuming that the planetary base program of Advanced Technology Development (ATD), Research and Analysis (R&A), and Mission Operations and Data Analysis (MO&DA) would be healthy. To our chagrin, those programs have taken large cuts in the fiscal year 1983 budget.

The cuts are of such magnitude and impact as to bring into question the validity of the SSEC effort.

Lower cost planetary missions will not come about by dictum. It is essential that proper ATD funds be applied to garner the perceived and desired technological and operational efficiencies and to assure better mission cost estimating and front-end credibility. As noted before, a part of the lower-cost approach to planetary missions is to more highly focus science objectives. This means, frequently, posing tougher more refined scientific questions to be answered. In turn this implies sophisticated, advanced instrumentation. Such instrument development, which ought to precede flight by about five years, has come close to a halt with the progressive cuts in R&A over the last decade.

In good conscience, it is difficult to recommend new flight missions if we are not making best use of missions in progress and data in hand. We also recognize that there comes a point of diminishing returns when it is time to stop operating spacecraft and to retire old data. However, the recent cuts in MO&DA clearly jeopardize still highly productive missions (Pioneer 6–11, Pioneer Venus), and data analysis activity (Viking, Lunar Sample). The corollary is the loss of a significant number of scientists and students from the program, part of the core of participants in the future planetary program, which we are trying to revive.

In summary, a high priority must be given to reestablishing the vigor of the baseline Solar System Exploration Program (and of other parts of Space Science). It is a challenge to do that in view of pressures to begin new missions. The disparity in cost between spacecraft and elements of the base program convince me that the two ought not to compete head-on but that sensible planning can allow both to proceed as we get the United States back on track.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. Why do you think that major corporations want to participate as development contractors in NASA's major scientific program when the rewards seem so minimal?

Answer. The rewards are not minimal. Three separate major corporation executives have told me that they strongly support a strong NASA science program and the reasons were identical. The bulk of their business is military and much of it classified. The NASA business is high visibility, exciting and high technology, all of which serve as an excellent lure for new engineers who can later be of benefit on "other programs."

Question. What is your future vision of NASA as an agency which support science, given the current funding priorities and the massive increases in the Department of Defense funding for space? What do you see as NASA's role, with regard to other federal agencies such as the DOD, NOAA, the Department of Agriculture and the Department of the Interior?

Answer. NASA must remain dedicated to the support of basic science. The current funding priorities and DOD space funding are related to either operational capabilities or to specific security mission needs. NASA, as a civil space agency, should not have its civil role preempted by those needs. However, where research and technology development can serve both the civil and military space programs, ways to more efficiently do that ought to be sought. I also see NASA research as a stimulant to the Departments of Agriculture and Interior. Cooperative programs are a necessity to assure that the applications needs of those Departments are taken into account in designing research programs and in sensor development while at the same time thoroughly exposing Department personnel to the latest data handling interpretation capabilities.

Question. What do you say to critics of the planetary program who say that we have had a decade of planetary exploration and should be moving onto other areas of research which need the resources just as badly?

Answer. I am not aware that "other areas of research which need the resources just as badly" are not being funded. Possibly not to the level they would like, but who is? I believe that the appropriate response is that one ought not to view planetary exploration solely as "pure science," but that it has aspects of exploration, vision, and national prestige that place it in a separate category. I do not maintain that it should not be examined critically—just that all relevant reasons must be brought to the fore.

Question. Do you feel that the scientific community is sufficiently plugged into the political and management process as it affects the decisions made on NASA's future research directions?

Answer. Yes, in general, NASA spends a lot of effort soliciting the advice of the scientific community through its own advisory panels and working groups and through the National Academy of Sciences. I feel that the external community could make a better contribution by being more willing to dedicate some of their time to the management function, especially in NASA Headquarters. There is one area of concern, however, that regards the next major effort in NASA in the manned space arena. While most of us realize that Apollo and Skylab and ASTP were not done "for science," these programs provided significant opportunities to accomplish good science. It was not necessarily the most efficient way, especially at the beginning of each of those programs. The Shuttle was, among other things, promised to be a useful, new tool for the conduct of space science. We have yet to realize that goal. I believe the potential is there but it will require several years of evolution before it is the "easy to get on board" system promised. (I am dismayed that NASA is apparently no nearer to extending Shuttle orbital stay-time to the highly desirable 30± days than it was three years ago. This is one example of a capability which could immediately enhance almost all kinds of Spacelab-based science). A danger lies in the possibility that the Shuttle will now be by-passed with the promise of easier and better science on a space platform or space station. An honest, hard look must be taken at where and how space science should be accomplished in the 80s and 90s.

Question. Do you feel that the limitation of the U.S. portion of the ISPM mission has had a major impact on opportunities for cooperative science programs with Europeans?

Answer. No. I do feel, however, that a more studied approach by both sides to international cooperation must be taken. In the recent past we have entered into too many cooperative projects for reasons largely of convenience to the U.S. This situation no longer exists in the sense that the U.S. does not have the monopoly (along with the USSR) that it had a decade ago. We must find better ways to uphold our commitments.

Question. Major scientific programs today sometimes take from 10 to 15 years from conception to pay off with flight data. Do you think that the scientific community is willing to pay the price for such a long term commitment in the face of continual threats of cancellation and deferral? Is something wrong with our system?

Answer. I think their patience is running out. Not so much in the community "on board" but in the younger researchers who are not committed to a career in space science. Yes, this says something is wrong with our system—we are going out of business but not as a conscious decision. If it were a decision based upon a deliberation of the Executive and Legislative branches, so be it, but to see a capability degrade because of lack of appropriate attention is inexcusable. I do not blame OMB and Congress alone—NASA and the science community need to make a more concerted effort at putting a higher priority on the baseline programs and in better definition/cost estimating/control of projects.

Senator HEFLIN. Thank you very much, Dr. Hinners.

Dr. Young, please proceed.

STATEMENT OF DR. ELIZABETH L. YOUNG, PRESIDENT, PUBLIC SERVICE SATELLITE CONSORTIUM

Dr. YOUNG. Thank you, Mr. Chairman. Our consortium represents over 100 users of space technology, including, I am happy to say, Mr. Chairman, the University of Alabama in Birmingham and the Alabama Educational Television Commission.

We believe that the evidence of this country's need for continued growth of space communications capacity is clear. We also believe that NASA is the appropriate agency to sponsor this high-risk technology research and development program. In this regard, however, we are increasingly concerned about the apparent downward trend of resources in NASA's budget devoted to research and development.

In the proposed fiscal year 1983 budget, for example, not only have the dollars for communications declined, but this activity represents a mere 1 percent of the total division budget for space science and applications.

We feel that today the need for NASA's continued work in this area is critical, particularly with regard to examination of new frequency bands, multibeam antenna, small Earth station technology, intersatellites links, and sophisticated baseband processing. These are all priority items requiring immediate study.

Two arguments have been offered as to why NASA should not continue in this direction. I would be happy to touch briefly on both of these. First, the argument has been made that advanced technology can be developed by industry. We recognize that industry has had a continually cooperative role with NASA especially in development of what has been called the 30/20 GHz program, in which our consortium is vitally interested.

But a flight program to test 30/20 GHz technology might cost between $250 to $400 million. A commercial firm is likely to spend at most $9 to $10 million a year in R. & D. Even aggregating the large manufacturers and carriers who have that type of budget brings us to a figure of perhaps a maximum $50 million a year that could be invested by industry even if they spend all the money in one place on one program, which is unlikely. Therefore, we believe that the numbers alone tend to refute the argument that industry can do the job.

Further, members of industry have testified before this committee and other committees in Congress that while they want to see NASA proceed in this direction and will cooperate, left to their own devices they are simply not able to aggregate the funds to take the high risks in technology research and development that will lead to opening up new frequencies in proving the success of high-risk technology.

Also, if we do not allow NASA to proceed, the threat of foreign competition in the market is real. From 1975 through 1980, for example, the average annual investment in Japan by their space agency and others was approximately $80 million for communications satellite technology at a time when NASA was spending less than $20 million a year.

Projections we have seen from the Japanese now show them spending in excess of $150 million per year for the next 3 or 4 years on communications satellites development and launches, while the budget for NASA's communications effort is falling rapidly.

At the same time, the Europeans, through the European Space Agency, may be spending as much as $540 million on L-Sat, also an extra-high-frequency satellite project.

The second argument that has been advanced as to why NASA should take a back seat in technology development has to do with the military programs, specifically MILSTAR. From what we have been able to learn, however, while some of the technology might be similar, the ability to transfer technology from that program to civilian uses will be limited, for a number of reasons:

For example, commercial or civilian applications will require high data rates, principally for television, complete control of the spacecraft from the ground, sophisticated baseband processors, and low-cost Earth stations.

The military, on the other hand, require a focus on jam-proof communications at a low data rate, primarily for voice, autonomous operations of the spacecraft and autonomous operation of the ground stations, with survivability in mind. MILSTAR will not employ regenerative processing techniques nor beam switching techniques, since it is likely to employ only a single beam.

For all of these reasons, Mr. Chairman, it is our consortium's conclusion in studying NASA's budget for 1983 that some additional $20 million should be added back into the communications budget to allow it to proceed on track with the very important research and development work it has been doing, particularly for the advanced communications satellite technology that Dr. Edelson mentioned. For the needs of the specific publics whom PSSC serves—health care practitioners, educators, Government administrators, rural Americans—additional communications capacity and services at the lowest possible cost are urgently needed. The combination of fixed satellites operating at high frequencies, in combination with low-power TV and cable—where appropriate—and other technologies offers an economical and practical solution to many public service delivery problems that currently exist.

Therefore, Mr. Chairman, we support the work NASA has been doing, and we urge that this committee allow NASA's work in this important area to continue. Thank you.

[The statement follows:]

STATEMENT OF ELIZABETH L. YOUNG, PRESIDENT, PUBLIC SERVICE SATELLITE CONSORTIUM

The Public Service Satellite Consortium appreciates the opportunity to testify today before the Senate Subcommittee on Science, Technology and Space. My remarks will center primarily around NASA's satellite communications program and particularly on the urgency of continuing research and development of advanced communications satellite technology.

The PSSC has been involved in assisting its members and others in using communications satellites and related technologies since 1975. Over 100 public service agencies comprise our membership. In the 1970's we coordinated experiments on NASA's Applications Technology Satellite (ATS-6) and on the United States-Canadian Communications Technology Satellite (CTS). For the past four years, the PSSC has arranged an increasing number of satellite transmissions on the commercially operated domestic satellites and, on occasion, in conjunction with INTELSAT spacecraft.

We believe that the evidence of this country's need for continued growth of space communications capacity is clear. We also believe that NASA is the appropriate agency to sponsor high-risk research and development activities that will result in improved services to users through the strengthening of U.S. industry. In that regard, however, we are increasingly concerned about the apparent downward trend of resources in NASA's budget devoted to communications research and development. In the proposed fiscal year 1983 budget, for example, not only have the dollars for communications declined but this activity is a mere one percent of the total division budget for Space Science and Applications.

We have been at such a juncture with NASA's budget before. In 1973, a decision was made that the agency should phase out of communications related research and development. Ultimately, that 1973 decision came to be viewed with dismay because the hiatus caused this country to fall behind the efforts of others—most notably the Japanese—in the development of improved space technology. When the Space Applications Board of the National Research Council published its 1977 report, "Federal Research and Development for Satellite Communications," it pointed out the urgent need for NASA to resume its work in communications. Other groups and representatives from industry concurred. The commendable result was a decision that

NASA should reenter the area of research, development and "new starts" relating to communications satellite technology.

The inertia of the mid-1970's not only eroded the U.S. position in telecommunications but slowed the ability of U.S. industry to capitalize on successful research and development. Today, the need for NASA's work in this area is critical. Continued examination of new frequency bands, multibeam antennae, small earth station technology, inter-satellite links, and sophisticated base-band processing are priority items requiring immediate study.

It is part of NASA's role to ensure that there will be sufficient capacity in space so that all the country's space communications needs can be served. The only way to accomplish this goal is to develop improved technology. In the past several years, some of the country's best university scientists and communications and aerospace engineers have worked with NASA to delineate a program that will provide for conservation of the electromagnetic spectrum and the geostationary orbit and will perfect transmission technology and techniques. This program has been popularly referred to as the "30/20 GHz" program. However, the emphasis should be less on the frequencies (although it is important to open them up to commercial exploitation) and more on the technology that will be developed. At this stage, the program is ready for major funding that will culminate in flight testing of the relevant technology.

If the technology to be developed is so urgently needed and NASA has the expertise and mandate to provide it, why does the fiscal year 1983 budget reflect declining support? Two arguments seem to have been advanced by those responsible for the budget recommendations: that industry can be expected to make the major investment required to develop the communications satellite technology and flight test it; and that the Department of Defense satellite communications programs, specifically MILSTAR, will meet all civil needs.

The belief that industry can and will make the large investments required has been refuted by industry representatives consistently, before this Congress and in other forums. In March of last year, a working group composed of industry representatives who sat on a NASA internal advisory committee reviewed the question of NASA and industry in the development of advanced technology. The working group concluded that: "The expense and risk associated with a satellite flight program of really advanced character was beyond that which any one aerospace company or common carrier could be expected to assume." While industry will expend research and development funds on short-term projects with a high probability of commercial success, it is impossible for U.S. industry, especially in a time of belt-tightening, to find resources to develop and flight test technology that may require a multi-million dollar effort. A flight program to test 30/20 GHz technology is likely, for example, to cost perhaps $250 to $400 million, whereas a commercial research and development program in satellite communications as conducted by a carrier is more likely to be on the order of $10 million per year.

To provide an idea of the level of investment private industry is willing to make, we can look at what one or two companies are currently spending and project a gross industrial investment total. (I should note that research and development budgets committed to satellite communications are not generally made available publicly by aerospace companies, but we do have some recent indications that provide a base from which to extrapolate.) RCA Astro is an example if a contractor that has been working on the 30/20 program and is also one of the successful manufacturers of commercial communications satellites. In 1981, they had gross sales of $275M and a profit of nine percent. Their internal research and development and "bid on proposal" budget was $9M for both communications and meteorological satellites. Approximately $3.5M of that was focused on developing technology for communications satellites. Most of the $3.5M was directed at near-term business opportunities. Only $100,000 was invested in 30/20 GHz related technology. We can assume that Hughes and Ford have research and development budgets similar to RCA's, while GE and TRW probably have smaller such budgets. Others in the industry would be smaller still.

Comsat is more typical of a carrier than a manufacturer, and they have indicated in recent testimony that they invested $11M last year in research and development. With the exception of AT&T, we can safely assume that the other carriers are investing less than $10M per year on communications satellite work and much of what is invested is in the ground segment.

Thus, taking together the probable total internal research and development budgets of the manufacturers and carriers known to be working on communications satellites, we find that something around $50M per year may be invested, and virtually all of that in near-term business opportunities. The argument has been made that if industry pooled its resources, the necessary advanced communications satellite technology could be developed with little or no NASA support. These numbers tend to refute that argument.

Representatives of the aerospace industry and of the carriers have been working with NASA on planning for the 30/20 program, and the interested companies have planned to share in the costs of testing by providing the major components of the ground system. Our own organization has also indicated a willingness to share in experiments and tests. However, all evidence suggests that NASA will have to continue to provide the significant risk capital and manage the research and development through flight testing.

Alternatively, if we fail to allow NASA to proceed, the threat of foreign competition in this market is real. Recent information about the Japanese communications satellite programs over the past several years and projected into the mid-1980's indicate startling comparisons. From 1975 through 1980, the average annual investment (by NASDA, the Ministry of Post and Telecommunications and industry) was approximately $80M for communications satellite technology. (At the same time, NASA's budget for comparable activities was on the order of $20M per year.) Beginning in 1981, with the planning for advanced 30/20 GHz satellites and a new broadcast satellite, the Japanese will be devoting over $150M per year on communications satellite development, with the NASDA investments projected as rising steadily during the 1980's. (It should be noted that I am using "real year" dollars here both in the historical data and in the future projections, but even with adjustments for inflation, the comparisons are dramatic.)

At the same time, the Europeans may through the European Space Agency invest as much as $540M on their "L-Sat" project (an EHF satellite system), and they are moving ahead aggressively in developing requisite technology.

During all this, we have not only seen NASA's communications budget decline but the funding for the 30/20 GHz program specifically curtailed. Even with a "run out" total of perhaps $340M, the program is a bargain and could keep the U.S. competitive with its European and Japanese industrial competitors. It is our observation that the additional funds required to keep the advanced communications satellite technology on track would require an additional $20M in the NASA communications budget in fiscal year 1983.

Let me now turn to the other argument that has been made with regard to the development of important EHF satellite technology. When asked recently in a public forum about this Administration's commitment to the development of 30/20 GHz technology, the Presidential Science Advisor replied that the technology is viewed as important and that all the necessary development will be accomplished in the DoD programs.

Given the fact that much of the information about MILSTAR is undoubtedly classified, what we do know of the program at this point indicates that much of the advanced technology required for the commercial operations of communications satellites in the United States will not be derivable from MILSTAR. The basic reason is that the system drivers, and hence the related technology developments, are quite different for the military and the civilian applications. For example, commercial applications will require high data rates (principally for television), complete control of the spacecraft from the ground, sophisticated base-band processors, and low-cost earth stations. Military needs focus on jam-proof communications at a low data rate (primarily for voice), autonomous operations of the spacecraft, the autonomous operation of the ground stations (with survivability in mind) which will result in a cost penalty. MILSTAR will not employ regenerative processing techniques nor beam switching technology (since it is likely to have a single beam).

Apart from the comparability of technology, however, we must address the theory of technology transfer from the military to the civilian side. In our opinion, it does not work well in practice. Much of what will be designed and flown will be classified, thereby not even permitting the industrial suppliers to make known their work so that it can be replicated or adapted for civil uses.

It can also be noted that some fifteen years ago, a concerted effort was made by the Department of Defense and the Communications Satellite Corporation (Comsat) to design a joint military-civil long haul satellite communications system. This effort failed. It failed for the simple reason that the military and civil operational requirements and financial circumstances were so different that they could not be encompassed within one technological envelope. No evidence has been advanced to us to suggest that today's circumstances are any different.

Mr. Chairman, the market for space communications is growing. Industry estimates are that some 2,700 transponders may be required on the civil side by the year 2000. Even assuming reduced orbit spacing, the existing and projected C-band

and Ku-band domestic satellites are likely to fall short of meeting the need. Thus, the establishment of systems operating at 30/20 GHz with technology advances such as multi-beam antennas and beam switching working in conjunction with low-cost terminals will be imperative to make up the difference in available transponders. Without the opening up of new frequencies and the equally important testing of new technology, the costs of buying into communications satellite systems—at least for the public service sector and for small business—may well become prohibitive in a few years.

For the needs of the specific publics whom the PSSC serves—health care practitioners, educators, government administrators, rural Americans—additional communications services are urgently needed. The combination of fixed satellites operating at high frequencies in combination with LPTV and cable (where appropriate) offers an economical and practical solution to many public service delivery problems that currently exist. The PSSC, in its own study of the requirements for public service over the next two decades concluded last year that "a 30/20 GHz satellite system may be the most feasible" to meet the aggregated needs of those it serves. It would be tragic if the very populations who can benefit most from satellite technology are forced out by cost and scarcity.

In our view, commercial adaptation of advanced communications satellite technology can bring about improved interactive home-delivered communications services, educational video networks, electronic mail, inexpensive teleconferencing and many more services. These are a few examples of what is desirable for the community of users whom we serve. We view NASA's work on such related projects as search and rescue, mobile satellite communications, and thin-route systems as very important. Funding for all of these projects needs to be sustained. However, it is the work being done in the 30/20 GHz program that will result in the development of exceedingly beneficial technology which otherwise may be delayed to the serious detriment of our economy and the needs of our potential users.

Perhaps in a time when heightened attention to cost-benefit relationships is the order of the day a word should be added about the pay-offs of NASA's communications satellite work especially as we can see those pay-offs over the next ten or more years. In the period between 1962 and 1981, the NASA satellite communications research and development investment was approximately $610.7M (the equivalent of $1,481.8M in 1981 dollars). Not only have sales of domestic satellite systems and related communications services grown into a business of billions, but the taxes returned to the U.S. Treasury from these sales have been over $1,500M (in 1981 dollars). Thus, the government investment has been repaid.

As we look to the future, estimates of the demand for satellites and earth stations in the United States between the present and the year 2,000 project a 20 billion dollar market. A decision to let NASA pursue appropriate technology development that would result in commercial adoption in the 1990's would mean a capture of much of this market—as well as capture of at least some of the foreign market for advanced communications satellites. An investment by our government of some $350M (for the 30/20 program) could ultimately result in a credit by means of taxes paid back of some $1,100M in the United States alone. Even 50 percent capture of the foreign market could result in another $500M benefit by way of tax on foreign sales. Additionally, new jobs will be created, and there will be a "ripple" effect as those who use the technology stand to benefit and increase the productivity of their business and service offerings.

The PSSC recognizes the extreme difficulty of making priority decisions about budgetary matters in a time of scarcity. Given our 7 years of experience with NASA programs, however, we would respectfully submit that an investment now in research and development of critical communications technology will have tangible and intangible benefits for this country for many years to come. Some of the benefits provided, such as improved emergency warning and health care delivery services, are vital. We believe that the aerospace industry, the carriers and organizations like ours should stand ready to work with NASA and to contribute a "fair share" to technology development. We are prepared to do so.

This Subcommittee's support for NASA's programs in the past has been commendable. In addition to the careful review you are now making of the proposed fiscal year 1983 budget and plans, we urge that you reinforce the legitimacy of NASA's role in developing space communications. No other agency of this government can provide the necessary work that will lead to successful adaptation of advanced communications satellite technology for civil uses. If this message can be clearly delivered, progress will have been made.

Thank you, Mr. Chairman.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. Why do you think that major corporations want to participate as development contractors in NASA's major scientific programs when the rewards seem so minimal?

Answer. The rewards as viewed by the contractors may not be seen as minimal. For many such companies, much of their development work is classified; thus, the ability to do work with and for NASA gives them recognition that they could not otherwise gain. Secondly, in doing research these companies build a team of experts and often discover technology areas that should be built into their own long-range plans. Finally, they view the development work as an investment in their own future since if the new technology can be successfully proven, there will be an eventual transfer to industry for commercial exploitation. This has been precisely the case in past NASA work with communications satellites. For example, developmental work done on CTS (Communications Technology Satellite) has led to the advent of direct broadcast satellites. Contractors who worked on the CTS program can now become suppliers to commercial carriers who will operate the DBS satellites.

Question. What is your future vision of NASA as an agency which supports science, given the current funding priorities and the massive increases in the Department of Defense funding for space? What do you see as NASA's role with regard to other federal agencies such as the DoD, NOAA, the Department of Agriculture and the Department of the Interior?

Answer. If NASA's role is to be primarily in support of "pure science," there will be an erosion of public support since tangible payoffs to the country are not always immediately evident. Therefore, we see a mix of support for science and applications as being optimal for the agency. Work in the applications area can produce short and longer term results that benefit both U.S. industry and civilian users. Since much of the research and development work undertaken by DoD is both classified and also not directly applicable to civil needs, NASA must be able to continue with research and development efforts that benefit users who have other than military requirements.

With regard to NASA's appropriate role vis a vis other agencies, it can often provide advanced space technology required by these agencies for cost-effective applications. For example, if NOAA has a requirement for improved spacecraft performance with regard to remote sensing, it should be NASA's mandate to develop the appropriate technology. The same will be true for other agencies. Further, if there is a need for a coordinating agency with regard to space technology requirements, NASA can play this role. Even though Defense has its own r&d activities and budget, they have in the past relied on NASA for early development work on advanced technologies. There is no reason to argue against such a relationship for the future.

Question. What is NASA's role in communications now and where within the agency structure should this role be carried out? In the Office of Space Science and Applications or the Office of Aeronautics and Space Technology?

Answer. The communications program has been and continues to be the locus of development of advanced satellite technology to aid users and U.S. industry. Even with reduced funding levels, NASA's role in communications continues to be one of service to eventual users both within and without government. There is a strong research component and a strong applications emphasis that justifies the research and development. While we would not presume to make what is appropriately an agency decision about the location of the communications program, its present emphasis would seem to accord with its remaining in the Office of Space Science and Applications.

Senator HEFLIN. Dr. White, please proceed.

STATEMENT OF DR. ROBERT M. WHITE, PRESIDENT OF THE UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Dr. WHITE. Mr. Chairman, I am going to comment on the application of satellites to meteorology and weather and the oceans. I think it is fair to say that the Earth-orbiting satellites have revolutionized our ability to provide weather services. We almost had an ocean satellite, but it was canceled last year. We hoped we could do the same thing for ocean services.

Those of us who have been involved in this program for a number of years are impressed that these weather satellites are enormously important to the country. They provide early detection, continuous tracking, and improved warnings of severe storms, such as hurricanes, tornados, thunderstorms, and squall lines.

All one has to do is visit the National Hurricane Center in Miami or the National Severe Storm Warning Center in Kansas City, and it will confirm for even the most skeptical the enormous dependence of our national warning system on satellite data.

The impact of weather satellites on atmospheric science has been profound. The global weather experiment in 1979, in which five geosynchronous weather satellites were in orbit at the same time, have now demonstrated that we can extend the time range for our weather forecasts between 5 to 10 days. This has now been demonstrated at the European center for medium-range weather forecasting.

I am troubled in the face of what is clearly an enormously successful application of space technology and prospective applications in the oceans by what is now happening. Let me give you some examples of the things that I worry about.

The cost of space technology is increasing very rapidly, as we all know. With severely restricted budgets, we face a dilemma. For example, the cost of the weather satellites in the National Oceanic and Atmospheric Administration now approximates the total cost of the basic weather services of that organization. The dilemma we face is how much money we allocate to the space portion of weather observations and how much money we allocate to other aspects of the weather services.

We need the weather satellite information for the kind of weather services the Nation needs, and we cannot get rid of the rest of the weather services in order to have satellites. It is a dilemma, and something needs to be done about it.

The effects of that problem are now becoming evident, as we can see in the latest budgets of NOAA, where we are curtailing the polar orbiting satellites because there is insufficient funding for maintaining the present weather satellite system.

Our program for development of ocean satellites, in my opinion, is in a state close to disarray. While NASA is examining various ways of providing sensors to measure ocean conditions, we have no plans for an ocean satellite. And other nations are going ahead with development, building new satellites to observe oceanic conditions.

Last, we have had, since the beginning of the weather satellite program, a remarkable cooperative program between NASA and NOAA in which NASA took on the responsibility of development of sensors and the technology necessary for the operation of weather satellite systems and the funding of prototype systems. That may well be in the process of change with NASA informing NOAA that they want NOAA to take over the funding responsibility for that kind of development.

I can only conclude that if that does happen, given the kinds of budgets NOAA has been experiencing in the past, we are not going to have very much new development of the kind of technology and instrumentation that will be necessary for us to keep our weather satellites up to the latest in space technology.

These are the things that concern me, Mr. Chairman. It is not a rosy picture. Thank you, sir.

[The statement follows:]

STATEMENT OF DR. ROBERT M. WHITE,[1] PRESIDENT, UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Mr. Chairman, members of the committee. I appreciate the opportunity to comment on the meteorological and oceanographic applications of space technology.

Earth orbiting satellites permit the acquisition of environmental information from the entire globe, which was impossible to obtain by other means before the space age. Such information has revolutionized our ability to provide weather services vital to protection of life and property and to the economy generally. They promise to do the same for the provision of oceanographic services.

Weather satellites have been operational for about 15 years. Weather satellites have clearly demonstrated their worth in hazard warnings and their economic utility in agriculture; water resource management; air, sea, and land transporation; and in energy and environmental problems.

Ocean satellite systems in the U.S. and other countries are in the planning stages. The recent decision of the U.S. government to postpone development of its National Ocean Satellite System (NOSS) leaves uncertain the timing of the next U.S. ocean satellite. The few months of data obtained from Seasat, a short lived research satellite, were sufficient to foreshadow the very promising operational utility of such data.

WEATHER SATELLITES—CAPABILITIES AND IMPACTS

Let us take a brief look at the present weather satellite system. The U.S. system consists of both polar orbiting and geostationary satellites.

This weather satellite system is able to observe both global and local atmospheric phenomena. The polar orbiting satellites observe the same region on the earth twice every 24 hours. The geostationary satellites observe particular areas of the earth almost "continuously".

This combination of polar orbiting and geostationary satellites provides information on phenomena as small as tornadoes and thunderstorms, and as large as the planetary circulations. In addition to photographs of clouds, weather satellites also provide infrared measurements which can be used to calculate cloud heights and the vertical distribution of temperature. They yield data on sea-surface temperatures and ice conditions. From the motions of the cloud elements, observed by geostationary satellites, it is possible to obtain remarkable coverage of the winds in the atmosphere at cloud altitude. These wind observations can flow directly into the numerical calculations that are the basis of modern computer predictions of weather. Temperature and moisture soundings obtained by radiation measurements provide a definition of the mass and motion field of the atmosphere which are also required as initial data for numerical weather prediction.

The satellites perform other weather functions. One of the attractive features of U.S. meteorological satellites is the Automatic Picture Transmission (APT) System. For a very small expenditure, receiving equipment can be build or procured to display cloud information observed by the satellite as it passes overhead. This local readout of weather information is vital for nations in regions that do not have adequate conventional meteorological observations to describe weather conditions. These systems are widely used throughout the world. Hundreds exist in developed and developing nations providing indispensible data to local weather services.

The satellites also perform certain weather communications functions. The polar orbiting satellites have a data relay and location system enabling them to acquire observations from remote areas and from ocean data buoys or ships at sea automatically. Also, the satellites are used for the distribution of preocessed weather maps and charts. Maps and charts produced at the World Weather Center in Washington are distributed directly to ground receivers in many countries via the meteorological satellite.

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[1] These remarks are made in Dr. White's personal capacity and do not represent the views of the University Corporation for Atmospheric Research.

While weather data from satellites have become necessary elements of the weather system of all nations, they must be supplemented by conventional meteorological observations. Satellite data, for example, do not provide detailed observations close to the earth's surface needed to support all aviation or agricultural needs, provide hazard warnings, or serve many other applications. Nevertheless, the have radically changed the system for weather observation and forecasting.

Weather satellites now give us information over the global oceans and remote and uninhabited land areas hitherto only sparsely observed. They permit early detection, continuous tracking, and improved warnings of severe storms such as hurricanes, tornadoes, thunderstorms and squall lines. A visit to the National Hurricane Center in Miami, or the National Severe Storm Warning Center in Kansas City will confirm for even the most skeptical, the enormous dependence of our national warning system on satellite data.

These data permit location and tracking of midlatitude storms over ocean areas such as those that cross the west coast of the U.S. from the Pacific or those that move up the east coast of the U.S. in the Atlantic Ocean.

The impact on meterological science has been profound. The weather satellite has opened new possibilities for improving the accuracy and time range of weather forecasts. At the beginning of the space age, meteorological theory had outrun the capability to acquire the necessary observations. Theoretical developments in numerical weather prediction and the availability of digital computers required global observations for the practical realization of the applications of that theory to weather forecasting. The balance is now redressed and the observations necessary to enable extensions in the time range and accuracy of weather forecasting are at hand.

While much remains to be done, recent results, for example at the European Center for Medium Range Weather Forecasting in England, using data from the recent Global Weather Experiment in which a system of five geosynchronous satellites were simultaneously in orbit, suggest that it may be possible to obtain useful skill in weather forecasts on a day-to-day basis for periods as long as ten days. At our own National Meteorological Center in Washington, as a result of satellite-enriched data, longer range forecasts are also being made by computer. Increases in weather-forecasting accuracy have been documented.

Beyond the impact on weather services, satellites may be the only way to obtain observations necessary for the resolution of certain global issues which are dependent on the understanding of global weather and climate processes. A good example is the implications for global energy and food policy of the changes in climate likely to accompany increasing concentrations of carbon dioxide in the atmosphere resulting from the burning of fossil fuels. The systematic increase in carbon dioxide is documented by precise observations at many observatories. A doubling of the amount of carbon dioxide, expected to occur sometime during the next century, is postulated to cause an increase of about 3° C in the global surface temperature. This is a very large average increase of surface air temperature and would result in significant changes in the present global climate. Similarly, the recognition of the ecological consequences of the transnational transport of pollutants resulting in acid rain have raised sensitive political issues which will require much more fundamental knowledge of atmosphere processes. Many new kinds of global observations will need to be made and satellites can make these possible.

OCEAN SATELLITES—CAPABILITIES AND IMPACTS

The oceans are important to all nations as a source of food, oil and minerals, as a medium of transportation, and as a potential sink for the wastes of humaity. Our knowledge of oceanic conditions is poor because till now they have been inaccessible to systematic observation by economical means. Oceanographers have acquired information about this vast domain piecemeal—by surface ship observations. Gradually an understanding of some features of the oceans have emerged. What has been lacking is a synoptic view of the oceans on a regional or global basis, and this satellites promise to provide.

Ocean satellites however now place within grasp the possibility of new types of global synoptic observations, i.e. observations acquired from many different points in the ocean at the same time such as sea state and the topography of the sea surface, the depiction of ocean circulation patterns and information about the chemistry and biology of surface layers.

Senors planned for oceanic satellites are designed to provide this kind of information. Multispectral scanners can yield remarkable pictures of oceanic structure. A scatterometer can sense the roughness of the sea and surface wind information. Maps of sea-surface temperature can depict the nature and changes in ocean currents. Perhaps most remarkable of all, a precise altimeter, which can measure the height of the sea surface to about 2 centimeters accuracy, can provide knowledge which can be used to calculate the large-scale motions in the seas. Microwave sensors and synthetic aperture radars can depict ice conditions in the polar oceans.

In the face of the achievements in weather satellites and the favorable prospects for ocean satellites one would suppose that the national investment in these remarkable devices would be assured. Unfortunately this is not the case. I find myself troubled about the future prospects for these space applications. Causes of my concerns are several.

1. The rapidly increasing costs of space satellites present problems for future weather and ocean satellites within NOAA, the responsible agency for operation of such satellites. Within severely restricted budgets a meaningful balance must be struck between resources devoted to space observation and the remaining responsibilities of the National Weather Service. That balance may soon get out of hand. For example, satellite costs in NOAA are approaching the cost of the rest of the basic weather service. If these two essential functions have to compete one with the other for funds under limited budgets, we will face a dilemma of which of two essential activities we have to favor. Clearly we will not be able to close down weather services to maintain weather satellites and we cannot provide the kind of weather service our citizens need without weather satellites. It will seem strange that in the face of billions for space research and development, we cannot afford the funds for space applications in weather and oceanography.

2. Our program for ocean satellite development is now in disarray since the decision to terminate the development of the National Ocean Satellite System. NASA is examining ways to fly ocean sensors—but there are no approved plans for moving ahead. Meanwhile, we see other countries moving ahead with the development of ocean satellites.

3. A shift in NASA policy seems to be in the making, reversing a practice that has been most successful in bringing weather satellites to their present state of utility. For over two decades by agreement between NASA and NOAA, NASA has budgeted and been responsible for research, development and production of prototype devices for meterological satellites. NOAA has budgeted and been resonsible for procurement through NASA of operational satellites. This arrangement has served the nation well. NASA now proposes that these responsibilities be assumed by NOAA. In the present budget situation I see little prospect of NOAA being able to do this—and if they cannot, we will have no meteorological satellites in the future that can incorporate the latest technological developments.

Mr. Chairman, the outlook is not bright. Thank you.

Senator HEFLIN. Dr. Townsend.

STATEMENT OF DR. JOHN W. TOWNSEND, JR., PRESIDENT, FAIRCHILD SPACE & ELECTRONICS CO.

Dr. TOWNSEND. Senator Heflin, I would like to address the Landsat program. As far as I am concerned, a decade of highly successful research and development is ending in stalemate with all of us the losers.

The NASA budget before you contemplates completing Landsat-D, launching it in midyear, and then finishing work on the back-up spacecraft. Beyond this, and early data reduction, almost all activities, with the single notable exception of the development of the multispectral linear array, are to be turned over to the National Oceanic and Atmospheric Administration.

However, the NOAA budget is based on turning the Landsat program over to the private sector in the very near term. So far, no viable plan for doing this has come forth. I am told that most of the preliminary discussions with industry so far have involved propositions in which the company involved wants a no-risk arrangement guaranteed by the Government—something quite different from what the administration had in mind originally, I believe.

Complicating the situation are issues of proprietary use of the data, international relations, and possibly military security. The upshot of this situation is that a gap in Landsat coverage and data is almost inevitable.

Mr. Chairman, I am sure you are aware of the long and rocky road NASA has traveled with the many and varied users of Landsat data. At first, NASA did not really understand their needs and they, in turn, did not understand that NASA viewed the Landsat program as an R. & D. venture and planned to operate it that way.

Over the years the situation has improved considerably, but an important message still comes through from the users. They insist that in order to insure the development of a real market for Landsat data products, all users must be certain of two things—faster and better data handling and continuity of service in the future.

This is reasonable. In this instance, to be in the data reduction and handling or in the value-added data enhancement businesses, one must invest in expensive capital equipment which then must be used on a regular basis to recover this investment. One must also invest in R. & D. in how to tailor the basic data products to the specific needs of the individual ultimate users.

What is the situation today? Many groups are familiar with the use of multispectral scanner data but faster and better data handling will only come after the launch of Landsat-D and continuity of service in the future is very uncertain.

Government users still represent by far the largest segment of the market, the rest being made up of a large number of relatively small users. Aggregating this market is a real challenge, but Landsat-D has a brand new and potentially very valuable instrument aboard, the Thematic Mapper.

If past experience is any guide, it will take a number of years before the true value of the new products can be demonstrated and before the users can feel comfortable in implementing new systems to take advantage of its capabilities. So far, however, I know of no firm plans to handle Thematic Mapper data in other than a research mode.

Thus, we seem to have a chicken and egg situation with the Landsat program. The market will not develop without demonstration products but industry is not likely to invest very large sums of money in a satellite system without a market. As we know, the present administration is against technological demonstrations, hence the stalemate.

My solution to the dilemma would be to transition the data handling and reduction part of the Landsat program to the private sector as quickly as economically possible, but to delay the transfer of the satellite system itself well into the future. This means buying at least one or more new spacecraft to insure continuity of data and the development and understanding of the market.

To cut down costs, I feel strongly that firm plans should be laid to use the unique capabilities of the NASA Landsat Multimission Modular Spacecraft and the space shuttle to repair and service these satellites on orbit. We have learned how to stop expending launch vehicles; we must now learn how to treat spacecraft as capital equipment instead of eventual space debris.

Mr. Chairman, one final thought in summary. During the decade of the 1970's, we and the U.S.S.R. had space to ourselves. This is no longer true. Foreign competition, particularly in the space applications area, is arising strongly. Unless we change our course of action, we will surrender our leadership in earth remote sensing to the French, Japanese, and possibly others.

Furthermore, we will be doing it at a time when, instead of backing away, we should be even more vigorous in insuring that this country, not others, reaps the benefits of a decade of expensive investment in the Landsat program.

Thank you.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. Why do you think that major corporations want to participate as development contractors in the NASA's major scientific programs when the rewards seem so minimal?

Answer. I really don't know. Personally, I expect to see more companies drop out in the future. The only positive thing that can be said is that these missions require technical skills of the highest order and I suspect that participation helps to challenge a company's staff and keep it at the cutting edge of new technology.

Question. What is your future vision of NASA as an agency which supports science, given the current funding priorities and the massive increases in the Department of Defense funding for space? What do you see as NASA's role with regard to other federal agencies such as the DoD, NOAA, the Department of Agriculture and the Department of the Interior?

Answer. I would hope that NASA remains the single focus for the support of space science. DoD increases will certainly go into defense technologies and are unlikely to spill over in any significant way into the science arena.

I support the concept that gives NASA the lead role with respect to other agencies during R&D phases of space ventures but leaves operational systems up to the mission agency that requires and can support them.

Question. Do you feel that the scientific community is sufficiently plugged into the political and management process as it affects the decisions made on NASA's future research directions?

Answer. I think the scientific community has been quite involved, both politically and with the management process at NASA; however, it is not clear at all if the scientific community is sufficiently "plugged in" to high levels in the Administration above NASA.

Question. Major scientific programs today sometimes take from 10 to 15 years from conception to payoff with flight data. Do you think that the scientific community is willing to pay the price for such a long term commitment in the face of continual threats of cancellation and deferral? Is something wrong with our system?

Answer. So far, the scientific community has shown a surprising willingness to make long term commitments to scientific missions in space. Given the recent deferrals and threats of cancellation, I am sure there will be an adverse effect in the future. This would be especially true of the very best research groups who are capable of working in other allied fields.

Yes, something is wrong with our system but it isn't just with respect to space science. As a Nation, we seem incapable of making any long term commitments in space. If we are to maintain leadership, there has to be a way to commit the country to programs and projects that indeed can last well over a decade.

Senator HEFLIN. Thank you, gentlemen. I hope you will indulge the committee by responding to written questions that will be sent to you later and we would appreciate it if you would answer those questions and return them to us.

We appreciate your being here. We wish we could have a fuller discussion but there are certain problems. Thank you very much.

Mr. Jerry Grey, the administrator for public policy of the American Institute of Aeronautics & Astronautics will be the next witness. Please come forward.

I might say the Shuttle will land at White Sands at 11:07 and people can watch it here on TV.

Mr. Grey, I may have to leave you but after you get started you can finish, so there is no requirement of the committee that I have to be here. I am going to have to leave very shortly, so I would appreciate it if you will go ahead.

STATEMENT OF DR. JERRY GREY, ADMINISTRATOR, PUBLIC POLICY, AMERICAN INSTITUTE OF AERONAUTICS & ASTRONAUTICS, ACCOMPANIED BY DR. STANLEY G. ROSEN, CHAIRMAN, TECHNICAL COMMITTEE ON SPACE SYSTEMS; AND H. HARVEY ALBUM, CHAIRMAN, TECHNICAL COMMITTEE ON AIRCRAFT DESIGN

Mr. GREY. Mr. Chairman, we are going to be very short and we hope to finish before you leave. We have submitted a prepared statement. We hope that that will appear in the record.

I would like to introduce the people who are here with me today. Stanley Rosen is the chairman of our technical committee on space systems, and Harvey Album is the chairman of our technical committee on aircraft design.

We are here to talk about the NASA budget in two areas—space and aeronautics. The latter is a subject we have not heard very much about today. Dr. Rosen will speak about space; Mr. Album will speak about aeronautics.

The AIAA is a professional society of individual members. We do not represent the industry. Our members consist of engineers, scientists, the students that Mr. Minato spoke so strongly about earlier, and managers. We are obviously proponents of aerospace, but we are also citizens and we recognize the urgency of maintaining stringent budgets. I hope you will take our remarks here today in that light.

Dr. Rosen, would you discuss the space program.

Mr. ROSEN. Thank you, sir. Our prepared statement on the proposed NASA budget has been submitted for the record. I want to take a few minutes to expand on three specific areas of our text. First, in light of our Nation's justifiable pride in the development of the Space Shuttle, we cannot overstress our view that the United States is now at a crucial juncture in the evolution of our national space program and of our technical, economic, and military vitality.

Decisions made now will shape our future to an impressive degree. The Reagan administration and this Congress have a unique opportunity to enable or to stifle our emergence as a civilization which integrates Earth and space into an environmental and cultural continuum. With proper foresight, a hopeful future can again become a reasonable expectation for our people and for all humanity.

Second, I would like to point out that in our comments on the proposed budget we stress our concerns about the shortcomings in the planetary exploration area, in the applications area—specifically with respect to advanced communications technology—and in the development of new capabilities. We want to stress the importance of continued protection of our ability to efficiently procure additional Space Shuttle orbiter vehicles and the clear need for a new advanced upper stage and plans for advanced space platforms as well as the capabilities and technologies which support these developments.

Next I would like to point to three areas in which enlightened leadership is especially crucial. The present opportunity to create a national space policy which endorses stable programmatic commitments to well-considered long-range objectives must be seized. Stability will help insure program success within reasonable funding constraints, will enhance our country's respect in the eyes of the world and will encourage the development and retention of scientific and engineering talent and other capabilities crucial to this country's future.

Within such a framework the relative roles of the public and private sectors in the exploitation of space are now ripe for reexamination. It is clear that commercial interests will play an ever-increasing role in space activities. The current challenge is to identify those Government actions that can best encourage and stimulate the genius of our private sector.

Finally, we should now assess the appropriate posture of NASA with respect to all potential user communities. For example, the policies of open and complete release of information, which were so well suited to a program heavily oriented toward science, are now undergoing much-needed review, in an era in which both the commercial and the national security sectors are becoming increasingly dependent on NASA as a partner in space operations.

That concludes my supplementary comments to our written statement. We would be happy to respond to specific questions about the details you will find therein. Thank you.

Mr. GREY. I would like now to introduce Mr. Harvey Album, who is the chairman of our technical committee on aircraft design. He will address the aeronautics part of the NASA budget.

Mr. ALBUM. I will summarize what is in our statement and will present our conclusions almost as assertions. In our statement you will find all the necessary backup.

The first point is that progress in aeronautics is vital to our economy, security, and welfare. The second point is that we are living, to a large extent, off investments made in the aeronautical R. & D. in the past.

Between 1968 and 1980 our investment in aeronautical R. & D. has gone from about 17 percent of sales to 11 percent of sales. The aeronautical industry during this period of time, that is, the companies themselves, have invested between 2 and 4 percent of sales. This is fairly representative of a high technology industry. Some go as high as 10 percent of sales for products having much higher profits. The actual annual investment in aeronautical R. & D. decreased on the order of 30 percent in real terms during this period of time, mostly due to reduced Government investments.

The third point I would like to make is that NASA's budget in aeronautics is only 7 percent of NASA's total budget. It seems to us that this budget should be increased by a factor of 2. That would add 1.5 percent of sales to our R. & D. investment in aeronautics.

Fourth, let us recognize that in the current budget that is probably unreasonable, but if we just wanted to maintain the current level we would add between $25 and $35 million to the budget for aeronautics.

Fifth, this level would be necessary in order to sustain certain very important NASA programs. In our written statement we have pointed out seven areas in which programs should be increased. We have indicated our judgments of priorities which you might wish to consider. There are three areas that may require funding adjustments, three areas that probably should be reoriented, two areas that we believe are lower priority programs and which can be decreased in funding, and one area that should be transferred to the space program.

If you are interested, I would be very happy to discuss any of these items in greater detail. That concludes my statement.

Mr. GREY. Thank you. There is one other area in which we are prepared to answer questions. On a temporary basis I wear another hat, as Deputy Secretary General of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space. In addition to the subject of space as Dr. Rosen discussed it and of aeronautics as Mr. Album discussed it, we also would be willing to answer questions in that area.

Thank you very much for your attention. We will be pleased to answer any questions you have.

[The statement follows:]

STATEMENT OF DR. JERRY GREY, ADMINISTRATOR, PUBLIC ~~POLICY~~; DR. STANLEY G. ROSEN, CHAIRMAN, TECHNICAL COMMITTEE ON SPACE SYSTEMS; ~~AND~~ H. HARVEY ALBUM, CHAIRMAN, TECHNICAL COMMITTEE ON AIRCRAFT DESIGN ON BEHALF OF THE AMERICAN INSTITUTE OF AERONAUTICS & ASTRONAUTICS

The AIAA, as you know, is a professional society whose membership of over 30,000 individual engineers, scientists, managers, and students encompasses all the disciplines associated with aeronautics and space. We appreciate once again the opportunity to appear before this Subcommittee to express our views on the proposed fiscal year 1983 NASA budget.

As we have mentioned in the past, we believe that the NASA programs we are here to discuss today are essential to the future prosperity and security of the United States, and do, indeed, in the long run, serve to benefit all mankind. We are obviously strong proponents of aerospace activities. We also, we hope, are reasonable citizens, capable of taking a balanced view of the nation's fiscal problems.

We have consistently maintained the position that even in a period of fiscal austerity, the NASA budget is the wrong place to demonstrate parsimony, and we are therefore pleased this year to see what we believe to be a generally rational program proposed by the Administration. Given today's economic realities, a budget that keeps pace with inflation would be a reasonable expectation. Nevertheless, given the relatively suppressed level of last year's NASA budget, the level fiscal year 1983 budget (in constant dollars as measured by the Consumer Price Index) must be considered only as a holding action. We realize, of course, that this segment of the federal sector, as others, must be constrained until the nation's economy is again under reasonble control. For this reason, we support the overall of NASA activity proposed by the Administration as being a reasonable minimum, but strongly caution against further reduction. The NASA belt is already very tight.

Our statement today deals first with space, and then with aeronautics.

In space we have reached a major turning point in the exploration and use of this new environment.

The initial scientific reconnaissance of the solar and Earth-Moon systems has been extensive. Key applications of space-based systems to the civil sector have been accomplished, and extensive commercialization is now underway. Extended manned habitation in space has been demonstrated, and man's utility as a functional part of space systems has been proven. New transportation systems, most notably the U.S. Space Transportation System and the European Ariane, are now ready for service. These are all watershed points in our evolution into a civilization which integrates Earth and space into a continuous environmental context, an evolution we believe is both proper and inexorable. We now must look to the future.

We have identified for comment three general areas in which NASA has responsibility under the National Aeronautics and Space Act of 1958: space science, space applications, and the development of new capabilities for space operation. The chartered NASA role in these areas is clear, as is the agency's responsibility to maintain a close relationship with the national security sector. These are areas in which enormous strides will be made in the coming decades. Whether the U.S. maintains it mandated position of leadership, as we believe it should, will, as always, depend on the budgetary decisions made by this Congress. The programs and the policies which evolve over the next few months will set the course.

In space science, it is gratifying to see several important ventures progressing: Space Telescope (ST); Gamma Ray Observatory (GRO); Spacelab Payloads; Galileo; the single-spacecraft International Solar Polar (ISPM) Mission; two Explorers, the Active Magnetospheric Particle Tracer Explorer (AMPTE) and the Cosmic Background Explorer (COBE); mission definition activities for the Origins of Plasma in the Earth's Neighborhood (OPEN) Mission; and several others. The Life Sciences program, which is essential to our future manned activities, is also to receive adequately enhanced support. The significance of these projects has been discussed with you in the past, and will not be repeated here.

However, we would like to reiterate the expected bonanza of scientific information to be obtained by the Space Telescope and other orbiting observatories, as detailed in the October 1981 issue of Astronautics & Aeronautics. The continuation of the planetary program is also a vital element of our overall space science strategy, and is a major factor in international science cooperation. Our recent letter to the Administrator of NASA criticizing the termination of the US ISPM spacecraft was motivated in large part by the serious effect such a move has on the credibility of the United States as a partner for international cooperative ventures. Such cooperation is an appropriate and effective way to control the costs of science programs, which do, indeed, benefit all mankind, as we have pointed out on page 23 of the December 1981 issue of Astronautics & Aeronautics.

Enthusiasm at seeing these programs proceed is tempered by disappointment that program delays are introducing inefficiencies which appear as increased runout costs. This concern is perhaps best illustrated by the fact that the fiercest of the recent budget battles have been waged over previously-approved programs of the quality of Galileo and Solar Polar, efforts of considerable scientific and national-prestige value that NASA cannot conduct within these austere budgets as originally planned.

This year, many of NASA's fledgling programs are in a survival-is-success mode. But in one area, planetary exploration, the Administration has recommended a going-out-of-business budget proposal, with a drop of 24.6 percent over fiscal year 1982. Such an action would result in the disbanding of research groups, the closing down of operating spacecraft, and a waste of data for lack of analysis. Fortunately the House of Representatives Subcommittee on Space Science and Applications Subcommittee has acted to reverse what we consider to be the unwise decision to turn off Pioneers 10 and 11 and Pioneer Venus next January. Pioneers 10 and 11 are sailing through uncharted space. Their solar wind and cosmic ray detectors are well equipped to identify the heliopause, the boundary of the Sun's influence in the galaxy and a region that has never before been detected. Its nature, structure, and behavior may tell us how and why galactic cosmic intensities we see near Earth are different from those in the galaxy in general. No other spacecraft in this century has even a chance of reaching to these distances, while Pioneer 10 is already 25 astronomical units from the Sun (25 times as far as Earth). Pioneer Venus is sampling new regions of Venus's atmosphere as its periapsis rises. Its cosmic ray detector allows location of gamma ray burst sources in concert with Earth-orbiting spacecraft. The price of keeping these facilities alive and continuing the analysis of their data is truly a small fraction of the investment the American public has already made in them. We hope you will support the House action to reinstate them.

We are concerned that in planetary exploration the funding which supports the stimulation of embryonic ideas has all but disappeared. It is clear that the time has come to re-evaluate planetary programs to set a new direction for the future. We believe the outcome of current studies in this area could lead to the development of less expensive missions for the late 1980's and the early 1990's as well as planning for more ambitious manned missions in the future.

The AIAA also believes that serious consideration should be given to resuming detailed investigation of our own Moon. Although we have walked (and ridden) on the lunar surface, we obviously understand the Moon far less fully than we understand the Earth. Many square kilometers of the lunar surface are unexplored, and many challenging scientific mysteries remain.

In the area of space applications investments, which provide the nearest-term payback to the economy and to national security, the Administration is seeking to transfer mature capabilities into the private sector. We support this strategy, but are concerned that the resources committed to the applications program are insufficient to permit an orderly and efficient transition.

The philosophy underlying the entire Resource Observation program is to conduct all applications of remote sensing in conjunction with the user community—federal agencies; state, regional, and local governments; private industry; and the scientific community. While the current-level program is well established with the LANDSAT data source, it is becoming increasingly important that support be given to development of next-generation earth sensors and the satellite systems to orbit such sensors. We urge therefore that the fiscal year 1983 budget permit at least a modest start in advanced development efforts for resource observation. The proposed assumption of LANDSAT system responsibility by NOAA starting in 1983 is, we believe, a sound approach.

The keystone of the oceanic observation program is of course the NOSS system that was zeroed out in fiscal year 1982. We believe that this planned cooperative funded program by NASA, DOD, and Department of Commerce should be resurrected in the fiscal year 1983 budget with or without DOD support. In addition, we urge that definition and early development of essential instruments for the UARS satellite be expanded relative to fiscal year 1982 funding. We are pleased to see that the proposed Administration's budget does in fact contain an increase from $6 to $14 million for UARS experiments, as well as sustained support for the Earth Radiation Budget experiment. The latter will greatly enhance our understanding of climatic processes.

In view of increasing worldwide concern about quantitative trends in the Earth's ozone layer we are disappointed to find no funding in fiscal year 1983 for the Halogen Occultation Experiment, but cannot dispute its priority relative to UARS and Spacelab experiments. Continuing support for the AgRISTARS and Geodynamics program is also encouraging.

As we noted last year, the potential for commercial application of materials processing techniques seems especially bright, a fact not overlooked by the Germans, Japanese and Soviets. We welcome the House Subcommittee recommendation to restore $5 million to NASA research in this activity. It is a wise investment in the future, and we hope your Subcommittee will support it. Although we note that the last year has seen increasing interest from the private sector in this area, commercial materials processing in the long-term view will require a federally supported orbital facility to supply continuing power, thermal control, and other essential services.

It is in the communications applications area, however, that NASA's fiscal year 1983 budget is of particular concern to us. Last year, NASA presented a budget that supported their planned reentry into the satellite communications technology leadership role. Unfortunately, the Administration's proposed fiscal year 1983 budget of $12M is inadequate even for the continued development of key component technologies, and can only be interpreted as a going-out-of-business budget for communications.

Since 1975, the AIAA has strongly supported the need for NASA to fund technology development and demonstration in the field of satellite communications. Last July we again testified to a House Committee in support of NASA's program and, in particular, we recommended that Congress support their efforts to prepare for a flight test of the 30/20 GHz program. The rationale for this recommendation remains sound. We therefore strongly support the House Subcommittee's recommendation that $5 million be added to the fiscal year 1983 budget so that at the very least a reduced-scope 30/20 GHz demonstration program can be studied. We believe this important program warrants an even greater investment; we hope your subcommittee will see fit to take such action. The need for NASA leadership is even greater today than it was last year, when we made the same recommendation.

Communications and information systems are key technologies of the post-industrial age we are now entering, and are already an arena of intense international competition. History has shown that, for very understandable reasons, the communications industry alone cannot and will not provide adequate support for the advanced work needed now to support space communications systems of the 1990's. This type of activity, which is being aggressively supported by European and Japanese Governments, must be matched by a NASA lead effort if we are to maintain our preeminence in this important world market.

I want to reiterate at this point our view that the Administration's goal of moving applications programs to the private sector is sound. The immediate task is to identify and help resolve obstacles to effective and timely transition, while maintaining adequate technical support in the interim. Hasty or poorly planned actions here can have a significant adverse effect on our nation's economic, political, and military strength in the next decade. It therefore seems difficult to understand how an Administration dedicated to private-sector business development can cut back funds for technology transfer and technology utilization. The AIAA's experience in our special programs involving many of the Fortune-500 non-aerospace corporations has clearly demonstrated the usefulness of these relatively small efforts in bringing NASA-developed technology and services to the non-aerospace private sector, a function which is oriented precisely in the direction this Administration has identified to rebuild the nation's sagging economy. The House Subcommittee has recommended restoring $9 million to these critically important and cost-effective programs. We hope your subcommittee will agree.

The final area in which specific comment on the proposed space budget is in order concerns NASA's programs to develop new capabilities in support of space exploration. This is a key function of the civil space agency and, indeed, a major reason for NASA's existence. New capabilities make science possible and lead to new applications.

The principal development activity, and the cornerstone of the NASA budget, is the Space Transportation System. We salute the Congress and the Administration for sustained support of this program, which promises to make space transportation operations routine (in a sense approaching that of the civil aviation system) and to lead to new and dramatic capabilities in orbit.

As the STS moves from a developmental to an operational program, several needs are clear. First, all necessary steps must be taken to increase the flight rate and reduce operational costs, while maintaining reliability, safety and flexibility. Moreover, as the shuttle moves into operation, needed improvements must be incorporated. To improve performance, filament-wound solid rocket booster cases should be developed; we are pleased to note that defense needs have initiated this process, but are disappointed by the House recommendation to delete it from the fiscal year 1983 budget. External tank production facilities should be expanded, as requested. Moreover, although not in the administration submittal, purchase of needed long-lead items for Orbiter 105 and perhaps 106 should be initiated. As we testified last year, our analysis indicates a traffic demand which cannot be met by a four-orbiter fleet. If defense requirements call for dedicated vehicles, the situation would become even more critical. Not to keep the door open now for additional orbiter procurement would be short-sighted, since a break in production would be highly costly in the long run. We believe such insurance would be a sound economic investment.

At the same time, serious consideration must be given to defining the next-generation launch system, and to incorporating needed improvements into future operational vehicles. We believe the time is ripe for beginning to put STS management on a truly operational footing. Regardless of who operates the shuttle, that organization should be dedicated to operations, not development, and should be responsive to the needs of all users. Only when such an operational shuttle fleet is available can this nation consider dispensing completely with expendable vehicles. Until that time, our expendable launch-vehicle capability for civil missions should remain viable, especially in the light of overseas launch-services competition. In this context, to help keep the United States competitive in the launch service area, the government should identify and support methods for providing acceptable financing arrangements to all STS customers.

Unique shuttle capabilities which set the U.S. STS off from other launch systems must be demonstrated as soon as possible. The AIAA believes that the planned in-orbit repair of the Solar Maximum mission is especially significant, partly because it will restore to service a costly and important instrument, but particularly because it would demonstrate a unique and vital shuttle-based operation. We regret to note that the House Subcommittee has recommended deletion of this program, thereby freeing $58 million (from both fiscal year 1982 and fiscal year 1983) for the other valuable efforts it has recommended reinstating. It is truly unfortunate that so useful a mission has to be sacrified; we are convinced that in future years we will regret such a decision.

We must continue our support of Spacelab experiments, not only for their intrinsic value, which is high, but also to help reconfirm our stature as an international partner. In general, the shuttle should be exploited for its unique characteristics, not only to capitalize on our investment, but also to define the real utility of man in-orbit and the requirements for future capabilities.

In a budget which proposes over $1.7 billion for production of a new transportation capability, it is disconcerting, to say the least, that the Administration has allocated less than $12 million dollars (0.7 percent) to planning the next steps. The Advanced Programs element is key to the future of NASA and to the entire civil space program, and should be significantly strengthened. The $4 million reprogrammed into this activity by the House Subcommittee is therefore a big step in the right direction; we hope you will concur.

The foremost need now, and one which should be addressed immediately, is for an advanced upper stage for the Shuttle to meet mission requirements beyond the capability of the Inertial Upper Stage (IUS) and the Payload Assist Modules. The need for such a vehicle is supported in the conclusion of the "Upper Stage Alternatives for the Shuttle Era—A NASA/DOD Report to Congress", which states, "An Interorbital Transfer Vehicle (IOTV), since it would be optimally designed to meet national requirements, would be the best upper stage to meet the long-term performance and operational needs of both NASA and the DOD." Unless we begin immediately with the definition and development of an advanced shuttle-optimized high-energy upper stage, our nation's ability to meet future mission requirements will be severely constrained. Many people tend to forget that IUS was always intended to be an interim vehicle to fill the gap between the advent of the Shuttle and the advent of the Orbit Transfer Vehicle (OTV). The eventual need for an OTV was never in doubt, as the AIAA stated formally in 1972.

With the Shuttle transitioning to operational status, we should proceed aggressively with an appropriate OTV designed to meet our future national needs. The House action to reprogram $5 million toward Phase B studies in this direction is therefore most appropriate.

Similarly, as shuttle development is completed, NASA must initiate needed complementary capabilities. Our experience with space operations clearly indicates that an orbital terminal will be needed for shuttle operations. The uses of such a capability have been studied fully (see the April 1981 issue of Astronautics & Aeronautics), and the time is ripe for starting the long-term evolution of such a facility. We have already mentioned the need for a service platform to support commercial materials processing activities. In the longer run, such a facility could exploit more fully the unique characteristics of man as a useful part of the operating system.

The AIAA has recently published a comprehensive assessment of our understanding of man's ability to do useful work in space (Working in Space, 1981). As a result, we recognize that future orbital activity must use the flexibility, capability, and ingenuity uniquely offered by the human operator. The orbital base is an essential element in extended manned space operation. It appears, incidentally, that the Soviet Union has not misread this lesson.

What we are suggesting is not another Apollo-like program with steep budget spikes, but rather a sustained, long-term commitment to the orderly evolution of an orbital facility which can serve a multitude of essential functions, eventually including manned habitation. In addition to its more ultilitarian potentials, the continuation of manned space travel offers opportunities for unprecedented expansion of our collective consciousness, and, in the words of Louis J. Halle, provides, at last, "a hopeful future for mankind" (Foreign Affairs, Summer 1980).

Finally, NASA's Space Research and Technology Program provides the groundwork for future capabilities. It is the heart of NASA's future space effort. The establishment and maintenance of an appropriate technology base is key to our nation's well-being; this tenet is particularly appropriate to the U.S. space program. In addition to the technologies we have already mentioned, key areas which must be supported include liquid rocket propulsion, robotics and artificial intelligence, cryogenic handling, large structures, power generation, energy storage, and heat rejection systems. Much of this technology base will support developments needed to ensure national security; the AIAA is intimately familiar with these applications as a result of our annual review of Air Force space technology programs. We will not go into the needs within each of these areas, but we are prepared to provide you with details if requested. We are now in the process of preparing an Institute position on liquid rocket propulsion, and where therefore understandably gratified by the House Subcommittee recommendation to restore $5 million to this critical technology area.

Mr. Chairman, this concludes our prepared remarks on the proposed NASA space budget, but I would like to add a few closing remarks about the ongoing process within the government to develop a national space policy. The AIAA, naturally, has taken a strong interest in this process, and has itself prepared a proposed space policy which will be released shortly, highlighting our view of the framework into which future space activities should fall. I would like to discuss briefly several major tenets before we close today.

The results of present policy decisions will determine our course of activity for the rest of this decade and strongly influence it thereafter. It is important that space policy decisions receive public debate and not be unduly subject to partisanship or expediency. Undersecretary of the Air Force Edward Aldridge has recently stated (as quoted in Astronautics & Aeronautics, February 1982, page 25), "expansion of U.S. activity in space is inevitable." We share this view and we are dismayed by actions that would appear to indicate that the principal policy issue is how to cut back our civilian space program. We feel, rather, that the issue is how to conduct our present affairs with more foresight. This requires that three interrelated actions take place: we must look ahead and establish our goals, prioritize them, and develop programs to reach them efficiently. The suggestions offered here are an attempt at encouraging discussion of the first element: what our goals should be. We are hopeful that your subcommittee will not be silent in this debate, as you have an appreciation of the capabilities and potential of the space program that few policymakers possess.

Practically speaking, one generally has specific programs in mind when formulating policy; nevertheless, it is important to maintain the distinction between policy and programs: policy sets direction and goals; programs are steps that progress in those directions. Recent events in the space science approval process illustrate what happens when ths distinction between policy and programs is not made. Each program approval becomes a policy decision. Whether or not to approve Galileo has threatened to determine what the policy on pursuit of space exploration would be. The budget process is not necessarily the best route for establishing policy. If national priorities in space are established, programs to implement those policies can then be devised and implemented through the budget process. Not only would such an established commitment stabilize NASA's science, applications, and development programs, but it would help to maintain the broad base of dedicated personnel needed to carry out out nation's space ventures. The scarcity of U.S. citizen engineering graduates from American universities is due in no small measure to the budgetary turbulence we have suffered, and to uncertainties about the future. For the sake of this nation's vitality, a policy of stabilization and commitment is essential.

Finally, the policies mandated by the Space Act of 1958 in fostering international cooperation and maintaining separation between military and civilian space endeavors must be reemphasized, while preserving the technological synergism that is a natural byproduct of efforts is support of these sectors. These policies have been largely responsible for the respect and admiration of the U.S. space effort in the eyes of other nations.

Turning now to the subject of Aeronautics, we will present our views here today from the perspective of the AIAA Aircraft Design Committee, whose members hold leading positions in advanced design, development and requirements for military and civil aircraft. Our consensus of judgments is based on our independent review of the NASA fiscal year 1983 budget in terms of the impact that these efforts will have on future U.S. aircraft designs. Any given point of view does not necessarily represent the individual opinion of each and every organization represented by our membership or of every single member of the committee. I believe that you will probably receive a complete spectrum of opinions to consider from other sources. However, we were able to reach substantial agreement on the issues involved in this budget because of our commmon interest in advancing this nation's aeronautical capabilities.

There has been much testimony to Congress supporting the fact that progress in aeronautics is vital to our nation's economy, security and welfare. The aircraft and airline industry is a $60 billion business, second only to auto manufacturing in employment. Over the past decade, aviation products made the greatest single positive contribution of any manufacturing industry to the net balance of trade; in 1980 it was about four times greater than all the R&D funds expended by the Federal Government that year for both military and civil aeronautics. The average annual compound growth of civil aircraft sales was 21 percent from 1975 to 1980. This was the third largest growth rate among 50 major U.S. industries; only computer and brokerage firm sales grew at a greater rate. The United States produced about 80 percent of all the free world's aircraft now in service. The market prospects for aviation products over the next 10 years are almost parallel peacetime aviation history. Yet, these facts do not nearly reflect the profound impact that progress in aeronautics has on our nation.

The extent of economic activity in commerce directly due to the availability of efficient and economical air transportation is beyond measurement. We can only imagine the tremendous dollar volume of business transacted and conducted through air travel. Progress in aviation has brought forth a vast geographic expansion of markets for large and small American companies, extending them to the full extent of our nation's boundaries and far beyond into world markets. American companies are effectively employing world labor pools and operating major international subsidiaries in the conduct of worldwide commerce activities. U.S. airlines carried roughly 130 million business passengers on domestic routes, 11 million business passengers on international routes, and 14 million tons of high-value freight in 1980.

This volume of activity, furthermore, has been carried out at ever-decreasing unit cost. Progress in aircraft designs has yielded almost continuous decreases in the average price of air travel, reducing it from $17 to $10 per 100 miles between 1960 and 1978 (in constant 1980 dollars). These major airline price declines occurred before the advent of deregulation. Meanwhile, the costs of rail and bus travel have escalated with inflation, making them no more than 20 to 30 percent lower than air travel. American aviation has grown to include over 200,000 civil aircraft, 15,000 airports, 800,000 pilots and 400,000 aviation ground support personnel. Large corporations and even moderate-sized businesses are not only using commercial airlines, but are also operating their own aircraft for executive and basic transportation. Industries are dispersing plants to regions in the nation that provide more efficient operations, lower labor rates and often a higher quality of life. Aircraft and helicopters are used in oil operations, agriculture, logging, forest-fire control, banking, police patrol, border and coastal patrol, and emergency evacuation. The impact of aeronautics on our nation's economy clearly extends far beyond the mere value of aircraft and airline sales. Governmental support for aeronautics is important, in an economic sense, because of the additional momentum that progress in aeronautics provides to our nation's overall economy and world economic development.

The U.S. Government itself must have aircraft for national defense. Over on-third of the total value of aircraft, engines, and parts manufactured in the United States are sold to the military services. These purchases must increase substantially over the next 10 years, for bombers, transports, airborne control and warning aircraft trainers, helicopters, light utility aircraft, remotely piloted vehicles, cruise missiles, and other air-launched missiles. Military aircarft and air-breathing missiles provide high flexibility to rapidly project military power.

Our nation's progress in aeronautics and the growth of this great industry has not been a matter of natural economic evolution or the pure force of private enterprise. From the very beginning, the Federal Government has been a major force behind the advancement of our aircraft industry. Military funding for R. & D. has always played a primary role in aeronautical progress. The National Advisory Committee for Aeronautics (1915-1958) and later the National Aeronautics and Space Administration (1958-present) have from the earliest days provided a common pool of systematic long-term research, technical advice and assistance on development programs, and first-rate aeronautical facilities for use by all aeronautical R. & D. sectors. The relationships between government agencies, industry, universities, and research institutes in this country has provided a unique and highly successful combination that must be strengthened in the years to come. Other nations recognize what we have done and are providing governmental support for aeronautics, including research support and direct financial assistance to their aviation industries. These countries are now making substantial progress relative to the United States in many areas and are reaping some of the same rewards that we have enjoyed.

The fact is that we have, to a large extent, been living off investments made in the past. We are not plowing back enough money into aeronautical R. & D. for the future. The total national investment in aeronautical R. & D. has dropped steadily from about 17 percent of sales in 1968 to 11 percent of sales in 1980. The actual total national investment in aeronautical R. & D. declined about 30 percent in real terms, considering inflation. The Government remained the prime source of R. & D. funds. However, our military services have become less aggressive in pursuing major advances in aeronautical research, technology, and prototype aircraft than in earlier years. The aeronautics industry maintained its own R. & D. investments at roughly between 2 to 4 percent of sales within this period. This level of industry investment is consistent with the average R. & D. investments of most other high-technology industries, although some invest up to 10 percent of sales in products which bring higher profits. The aerospace industry, which consists largely of the same firms engaged in aeronautics has after-tax profits only between 2 to 5 percent of sales during this period. The average profits of aerospace firms were generally 1 or 2 percentage points below the average profits for all manufacturing companies over the last decade (based on assests, equity, or sales). Hence, the aeronautics industry is not in a financial position to take major risks or make substantially greater investments in aeronautical R. & D.

Yet, progress in aeronautics requires the highest investment in R. & D. of any industry because it is our highest technology industry. The level of technology for aeronautics is evident from the total figures on the required R. & D. investment as a percent of sales. Furthermore, except for space and missiles, the aeronautics industry requires roughly twice as many engineers and scientists per 1,000 employees as any other U.S. industry. A single new aircraft design incorporates the latest developments in such high-technology areas as computers, electronics, structures and materials, propulsion, fuels, aerodynamics, and controls—all brought together into a single, minimum-weight, durable machine. The resultant aircraft must withstand the daily use of an airliner or the rugged environment of a military aircraft in war. Without Government effort to continually upgrade research and technology, we will be left with a private industry that will focus only on limited near-term research and low-risk concepts that can provide it a near term competitive edge. Aircraft manufacturers cannot afford to do otherwise with their limited individual economic returns. Government support is justified by the extraordinary expenditures requied for this, our highest technology industry, and by the extensive benefits that advances in aeronautics provide to our overall national economy, security, and welfare.

The NASA budget represents an important portion of our governmental support for aeronautical R. & D. The technical data, theories, and new concepts available from NASA provide our competitive free-enterprise system a valuable common pool of practical research and technology to develop alternative solutions for military, commercial, and general aviation aricraft. The NASA aeronautical facilities provide a common capacity for experimentation, computation and testing. This agency's technical capabilities, facilities, and technical results simply could not be duplicated in industry, and it would be extremely inefficient for each company to attempt to duplicate them individually. Hence, NASA programs are important to aeronautics when they are correctly oriented and properly funded.

Turning now to the NASA aeronautics budget, we support its general thrust and even many of the program changes that have been made. However, the fundamental problem whith NASA's aeronautics budget is its magnitude. The total proposed for aeronautics is $494 million in fiscal year 1983. Support for aeronautics is only 7.5 percent of the total NASA proposal. The NASA budget for aeronautics has declined over 30 percent in real terms over the last 2 years. The total amount allocated to aeronautics should probably be about twice as large, which would add about 1.5 percent to the nation's investment in aeronautical R. & D. relative to product sales. The proposed NASA funds for internal aeronautical laboratory research operations and program management ($243 M) and facilities construction ($19 M) are respectively 21 percent and 19 percent of the NASA budget for the same categories. However, the proposed aeronautical contract R. & D. budget ($232 M) is the most debated part of the aeronautics budget, even though it is only 4 percent of NASA's total R. & D. contract budget. This portion of the NASA aeronautics budget has been cut by over 60 percent in real terms in the last two years. At the very least, we recommend an increase of $25 to $35 million in the NASA fiscal year 1983 aeronautics budget.

The general thrusts proposed for experimental, analytical, and computational research in aerodynamics, propulsion, structures and materials, and flight controls are extremely important to maintaining this nation's strength in aeronautics. NASA's aeronautical facilities for wind tunnel testing, numerical computations, and flight simulation should be expanded, improved, maintained, and operated based on the high demand for them. These facilities must provide not only high-quality tools for NASA research, but also a major portion of the aeronautical facilities capacity to be shared by all aeronautical R&D organizations in the United States. In certain select cases, NASA should play an important role in advancing aeronautical technology, systems technology, and hardware systems technology demonstration. However, there must be a particularly good fit between NASA's technology programs and the technology programs naturally undertaken by industry, the military services, and other governmental agencies. The potential results of NASA's technology programs must warrant their costs, which tend to be markedly higher then for basic and applied research. The funding and manpower for NASA's technology programs must not displace or submerge NASA's high-priority, creative, long-term research programs. The proposed NASA aeronautical program for fiscal year 1983 largely fits these criteria and thus, in principle, we strongly support this program.

There are, however, specific program areas and cases in which we disagree with the budget. Reemphasizing my statement that the views expressed here reflect only those of the AIAA Technical Committee on Aircraft Design, I will discuss these items in order of importance under each major budget category and assign each recommended change a number representing our judgment of its relative priority to NASA's total aeronautical activities. The numerical priorities may be considered on this scale: 0—should be dropped, 1—is questionable, 2—is valuable, 3—is extremely valuable and 4—is of highest importance. All the NASA programs that we support in the budget have a priority of 2 or higher. Hence, our recommendation for a program with a priority of 2 or more is a good rating on our rather conservative priority scale. The changes recommended for any program should result from equivalent increments in the total NASA aeronautics budget.

High-Speed Aircraft Systems Technology Programs.—In our opinion, NASA should increase the budget for the High-Speed Aircraft System Technology Program by at least $3 million, giving a total program budget of $23 million (Priority 3.4). NASA should stress joint systems technology programs with the Air Force and DARPA on the Forward Swept Wing X-29, the Variable Camber F-111, and the Advanced Fighter Technology Integration AFTI-16.

HIMAT testing should not be terminated this year as planned. Large investments in time and funds have been made in the HIMAT vehicle, supporting ground systems and associated research and technology efforts. As of this date, only about 16 flight tests have been completed and these tests have all been subsonic. NASA seems reluctant to test this pilotless vehicle in the high-risk regime for which it was intended, namely under difficult control manuevers and at supersonic Mach numbers. NASA should test this vehicle under these high-risk flight conditions, regardless of the potential for vehicle destruction. The experimental flight results which would be obtained by testing under these conditions in terms of aerodynamics, structures, propulsion integration, and flight control characteristics can provide useful data for comparisons with theoretical predictions and ground test results. These comparisons will improve our ability to predict such characteristics and design future fighter aircraft for these flight conditions.

With regard to Supersonic Cruise Technology, we believe that supersonic vehicle research and technology can have valuable benefits to potential users in the military and perhaps eventually in the transport industry. However, NASA should not be conducting systems applications and mission analysis studies for military applications. This type of work is more appropriately planned, conducted, and funded by the military services, who have the responsibility, mission experience, and expertise for it.

Advanced Propulsion System Technology.—At least $10 million should be added to the NASA budget for the Advanced Propulsion System Technology Program. This work should not be deleted from the NASA budget as proposed. The propfan is the most important area of work that should be funded under this program (Piority 3). It offers the prospect of high fuel efficiency, long range, and endurance for future military aircraft as well as for civil aircraft. The propfan could greatly influence the design of many type of aircraft in the 1990s. However, this technology is too risky now and its development is too far-term for industry or the military to pursue it without the propspects of lower technological risks and fairly well defined future applications. The energy-efficient engine program is also expected to provide useful results for more efficient civil and military jet engines in the future (Priority 2.4).

Propulsion System Technology.—We recommend a budget increase of at least $2 million for the Propulsion Systems Technology Program, rather then deleting it as proposed in the NASA budget (Priority 2.7). NASA should continue to pursue transmission technology efforts applicable to all rotating propulsion systems, without reduction in the current level of effort. The development of advanced concepts and analytical techniques for transmission systems will benefit both military and civil aircraft efficiency, reliability, and maintenance costs.

Transport Aircraft Systems Technology.—We recommend that the NASA budget be increased by about $12 million for transport systems technology (Priority 2.5). This work is generally applicable to civil and military transports, as well as other large military aircraft. The most important area of work that should be funded under this program is composite aircraft structures (Priority 2.5). The art and technology of designing and constructing large composite aircraft structures has not been achieved. Composite structures offer the potential to achieve lighter, more efficient aircraft or longer range and higher endurance military and civil aircraft. Composite structures technology can also affect such military characteristics as the aircraft radar signature and aircraft size, both of which influence aircraft stealth. The Terminally Configured Vehicle Program (Priority 2) and energy efficient transport activity (Priority 1.9) are also expected to yield useful results for both military and civil applications. The laminar flow control program is of lower relative priority, in our opinion (Priority 1.3).

Other Systems Technology Program.—We fully support the remaining fiscal year 1983 allocations and actions proposed in the NASA budget for the other Systems Technology programs. The Low-Speed Aircraft Systems Technology Program should be funded as planned. NASA work on avionics systems technology slated to transferred into the technology base seems of lower priority then NASA's other programs. Substantial work is underway and will probably be funded by the military and commercial sectors at funding levels exceeding that of the NASA effort in this area.

Aerodynamic Research and Technology.—The planned budget for the Aerodynamic Research and Technology Program should be increased by at least $3 million, giving a total of approximately $44 million (Priority 3.6). We recommend this modest, but important, increase to support expansion of systematic applied aerodynamic research on aircraft components and integrated configuration. Such research provides aerodynamic design alternatives for improved configurations, rapid prediction methods, and a systematic related data base for aircraft design application. The expanded NASA program should emphasize experimental research and comparisons of data with analytical theoretical approximations, semi-empirical theories, and conputational methods that can be used readily in the aircraft design process over the next two decades. NASA's work in aerodynamics should cover subsonic, transonic, and supersonic Mach numbers. We also support NASA's planned applied aerodynamic research efforts under the Low-Speed and High Speed Research and Technology Program line items in the budget.

High-Speed Research and Technology.—The budget for High Speed Research and Technology should be increased by at least $4 million, for a total of $31 million (Priority 3.2). We recommend this budget increase to support operation of NASA's extensive wind tunnel facilities for aerodynamic, structural, and propulsion research. NASA is strapped for funds for wind tunnel operations at a time of record schedule backlogs, which are now booked 2 to 3 years into the future. For example, we understand that NASA Ames is planning to close down its 14-foot wind tunnel, in spite of years of backlog work, simply because there are not enough wind-tunnel operating funds. The internal NASA laboratory research suffers most in this environment; time-urgent test programs for the military and civil users tend to receive priority in NASA wind tunnels. The proposed budget increase will go a long way toward enabling NASA to use its wind-tunnel capacity to meet the high demand placed on it.

We generally support all of the planned work under the High-Speed Research and Technology Program. However, the work on engine nozzles should be systematically broadened to cover a wider spectrum of engine nozzles, rather than just two-dimensional nozzles. There are many potential cases in which axisymmetric nozzles are more appropriate for future applications.

Transport Research and Technology.—Transport Research and Technology should by funded for about $6 million under the other budget items to which NASA has assigned it (Priority 2.5). NASA's work on transport research and technology should be continued because of its possible long-term value to military transport aircraft, airborne warning and control aircraft, long-range sea control aircraft, and other military applications, as well as to civil transports. The total NASA budget should be appropriately adjusted to provide this funding if it has not been fully included, without decreasing the other planned aeronautical R&T activities under those budget items.

General Aviation and Commuter Research and Technology.—We strongly support continuing NASA general aviation research and technology efforts at a level of at least $8 million under the new budget categories to which it has been assigned (Priority 2.5). Of highest priority is the propulsion work on fuel-efficient engines, low-speed propellers, alternate and multi-fuel engines, and improvements in propulsion/airframe integration. The areas of work conducted under general aviation R&T are important not only to civil general aviation and commuter aircraft, but also to future light military aircraft.

General aviation to this day draws heavily on the wealth of knowledge developed by the National Advisory Committee for Aeronautics (NACA) prior to 1958. Over the last five years or so, NASA has again been moving forward in this area by replenishing the common base of research and technology by improving prediction methods, expanding the experimental data base, and providing new concepts in such critical areas as propulsion and wing design. General aviation companies cannot and would not provide a common base of knowledge of this kind. We believe that NASA must increase rather than slacken its research for this segment of the aviation industry. We are living in a time when other nations such as Canada, France, Germany, Brazil, Japan, and Spain are wisely providing heavy government research and financial support for their general aviation industries, and they are making relatively great progress in this area.

Other Research and Technology Programs.—We strongly support NASA's planned programs and the relative budget levels on NASA's other research and technology base efforts; i.e., propulsion, materials, structures, and programs in the low-speed, high-speed and multidisciplinary areas. The NASA factors contract R&D program seems to us to lower priority than NASA's other aeronautical programs, in view of the responsibilities and substantial efforts in human factors being conducted by the military, industry, and the FAA. However, such work might be justifiable under a substantially larger NASA budget.

We support all aspects of NASA's aircraft control and guidance research and technology, except the work on shuttle handling qualities. While the shuttle work seems worthwhile, the funding for it should come out of the space budget. The research and technology R&T line item should not be decreased in the aeronautics budget with the transfer of the shuttle work to the space budget.

Wind tunnel facilities.—The budget should be increased by at least $2 million this year and more in later years for increased maintenance and repair of NASA's wind tunnels (Priority 3.2). These wind tunnels represent the largest investment of their kind in the free world. Most of the facilities are 20 to 40 years old. A continual investment must be made selectively to upgrade and improve these facilities across the board to keep them effective and efficient, consistent with demand.

We strongly endorse the other items in the NASA aeronautical facilities budget proposal.

In closing we express two general concerns about planned alterations in NASA system technology programs. First, we are concerned that the cancellation of high-visibility systems technology programs and subsequent reassignment of portions of this work to the research and technology base may actually lead to undesirable decreases in high-priority R&T base work, even though the budget is increased in this area. Second, we believe that the emphasis on joint NASA/DOD system programs can be highly beneficial, if they are properly structured. However, it is important that NASA laboratories do not become mere extensions of the military laboratory system or "independent military laboratories of another kind." NASA must increase its innovative, systematic, long-term research to provide a superior practical base of knowledge for designing both military and civil aircraft. NASA's major research thrusts should be reasonably stable and not subject to frequent major alterations due to fluctuations in military priorities.

Mr. Chairman, we thank you for this opportunity to present our views, and will be pleased to answer the Subcommittee's questions to the best of our ability.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question. Looking ahead in the next ten years, what do you see as NASA's role as part of the overall national space program?

Answer. Through the 80's, NASA must continue to insure that the United States retains preeminence in space activities, in accordance with its chartered role. In this capacity, it is essential that NASA continue to develop advanced technologies which enable new and more effective space missions for all sectors of the U.S. space program.

NASA must also focus on emerging applications of space capabilities to meet civil, commercial and national security needs, in concert with the plans of these communities. The most significant of the civil applications include advanced remote sensing capabilities, communication and data processing technology, and material processing techniques.

The development of capabilities which facilitate improved space operations by all sectors should continue. Foremost must be the evolution of the Space Transportation System into a truly cost-effective operation, with sufficient fleet capacity, competitive costs, and advanced orbital transfer capability. In addition, development of an orbital terminal for the space shuttle, potentially including extended manned activity, should be pursued.

Finally, NASA must continue to be at the forefront of global space science activity, with aggressive programs to explore the Earth, Moon, Sun, planets and stars, and the medium in which they are embedded.

Question. In what areas of technology development and research do you see a need for a greater emphasis over the next ten years if we are to maintain a competitive space program?

Answer. To insure competitiveness in areas promising commercial application, research and development support should be increased in the areas of materials processing, Ka-band communications, and advanced sensor technology for remote sensing systems. Among key technologies which support effective space operations are data processing, including development of more autonomous space systems and robotic operations, large structures and their associated control and stabilization, and high data rate communications, including laser systems. In addition, progress must proceed in such basic areas as propulsion, power generation and control, energy storage, thermal management, and materials for enhanced structural and thermal stability. Finally, advanced life support systems will be needed for effective long-duration manned space activities. Specific areas can be provided by AIAA Technical Committees, if desired.

Question. In what commercial areas do we face the greatest challenge from foreign nations? What might be the impact of this competition?

Answer. Four areas of space activity in which commercial competition will be most intense will be launch services, communication satellites and services, materials processing, and possibly remote sensing.

Compeition from European and Japanese launch capability will initially meet the need for services which exceeds shuttle capacity. More aggressive commercialization of Delta and perhaps Atlas and Scout vehicles would put the U.S. in a better competitive posture in this time period. In the longer run, as the shuttle becomes the primary and possibly exclusive U.S. launcher, it will encounter even stiffer competition from foreign vehicles. The net effect could be loss of potential customers and hence lower revenue to the U.S. On the other hand, such a diversity of launchers provides a desirable range of choices for U.S. satellite owners, giving them the ability to discriminate regarding cost, ease of integration, liability, etc.

Competition to provide communications satellites and related services is already intense and is expected to grow. Again, the impact would be loss of revenue to the U.S., as the U.S. and foreign companies purchase hardware and services abroad. This trend would, in the long run, also weaken the U.S. industrial base and, potentially, our ability to field needed military systems.

Although neither materials processing nor remote sensing areas have been commercialized, both offer potentially large commercial opportunities. In these fields as well, an inadequate competitive posture would lead to a forfeiture of future income. In any event, it can be anticipated that intense competition may stimulate evolution of these capabilities and technologies as markets develop and expand. In this sense, competition will be healthy for U.S. industry.

In aeronautics the U.S. faces ever-stiffer competition in virtually all sectors of the industry. The European Airbus has already made major inroads into the transport market formerly dominated almost totally by U.S. manufacturers. The U.S. share of the world helicopter market has been dropping precipitously, and continues to decline as more and better European machines reach and pentrate the market. Even in general and business aviation, once almost wholly dominated by U.S. products, foreign aircraft are now almost as prevalent as those made in this country. And although our military aircraft retain their primary position in the global marketplace, aggressive selling by the French and others, mainly because of strong support by their governments, continues to threaten that leading position.

INDIVIDUAL RESPONSE FROM H. HARVEY ALBUM

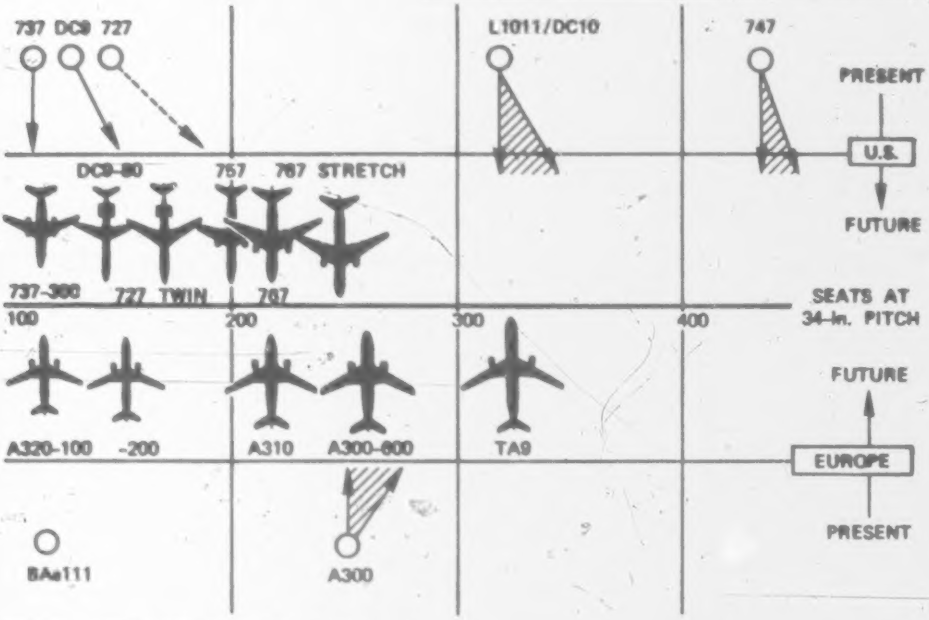
Question. In what commercial areas do we face the greatest challenge from foreign nations? What might be the impact of this competition.

Answer. The American Institute of Aeronautics and Astronautics has appropriately responded to this question. However, I would like to add some additional individual observations and opinions of my own.

COMMERCIAL CHALLENGES IN AERONAUTICS

Commercial Transports.—European subsonic commercial transports and related technologies have been rapidly advancing and soon will be traversing a point of general comparability to those of the United States. The attached figure shows that in the near future, U.S. commercial transports will be in head-on competition with European transports almost throughout the entire spectrum of seating capacities, except for that of the very large Boeing 747. Boeing is also considering a short-range aircraft of 150 seats called the Boeing 7-7 that will compete with an Airbus A-320 aircraft of the same seating capacity. The Europeans surpassed the United States almost a decade ago in supersonic transports, since they have one and we do not.[1]

EUROPEAN MANUFACTURERS OFFER COMPETITIVE AIRCRAFT
FOR SHORT/MEDIUM HAUL FOR THE 1980s-1990s



SOURCE: AIRBUS INDUSTRIES (March 1981)

The European industry is also advancing strongly in commercial aircraft subsystems. European jet engines are comparable to similar engines manufactured in the United States. The navigation, flight controls instruments in European commercial transports are as advanced and reliable as those in U.S. aircraft—in fact, many of these systems were made in the United States. However, the Europeans are also moving ahead in avionics. They are also using very advanced European digital avionics and display systems in their transports. Avionics is a rapidly progressing field, and the U.S. is holding its own in the competition in this area.

Light Turbo-Prop Transports.—The attached table shows that foreign countries are well ahead of us in the light turbo-prop aircraft transport market. Light turbo-prop transports are suitable for the rapidly growing commuter airline market in the United States. In many foreign countries, light propeller-driven transports represent an important portion of the primary air transportation system. The quality and reliability of foreign aircraft and the related technology for light turbo-prop transports is equal to that of the U.S. manufacturers. However, foreign nations are obviously far ahead of U.S. manufacturers in fielding aircraft to compete for the light transport market. This situation is not simply a matter of basic U.S. technology or our capability to develop aircraft for this market. American manufacturers are reluctant to risk large amounts of capital to enter more deeply into competition in this area with foreign aircraft industries that are virtually all heavily supported by their governments.

Helicopters.—Foreign competition in the commercial helicopter market is greatest for light to medium twin-turbine helicopters. European helicopter technology and designs are commensurate with those of the United States. Helicopter R&D efforts in several European countries have been very strong. However, U.S. helicopter manufacturers currently have the largest market share—in spite of the recently stiff foreign competition. European helicopter manufacturers and their governments are clearly making a determined effort to gain larger shares of the U.S. helicopter market. A continual stream of new and improved European helicopters are coming on the market. The U.S. helicopter industry continues to excel in the areas of very light and heavy helicopters.

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[1] The Concorde is not a significant market factor at this time, nor will it be for the foreseeable future.

Business Jets.—The position of U.S. general aviation manufacturers in business jets is also being strongly challenged by foreign manufactuers (French Falcon Jet, British Jet-Stream, Canadian Challenger, Israeli Westwind and Japanese Diamond Jet). The technology and reliability of the new foreign business jets are excellent—equal to or exceeding our own. These foreign companies have strong government backing for R&D and sales financing.

Light Aircraft.—The United States still holds the dominant position for light fixed-wing aircraft. The one light aircraft area in which the U.S. is being strongly challenged is business turbo-prop aircraft.

General.—U.S. aircraft manufacturers currently hold a lead in manufacturing capabilities and productivity over foreign manufacturers. In addition, U.S. aircraft manufacturers have the advantage of well-established service support networks, market positions, and reputation.

NUMEROUS TURBOPROP COMMUTER AIRCRAFT INTRODUCTIONS ARE ANTICIPATED THROUGH 1985; MAJORITY WILL BE FOREIGN MANUFACTURED

	Seats				
	10–19	20–29	30–39	40–49	50–59
Current models	N-24A DHC-6 EMB-110 Skyvan Metro BN-2A	C-212-200 IAI-102 G-1C	SD-330 AR-404	HS-748 F-27	DHC-7
Models expected to be on production before end of 1982.	Jetstream 31 C-99 Do. 228	Metro III [1]	SD-360	DHC-5E	None
Other designs committed for production.	B-1900	None	CN-235 DHC-8 EMB-120 SF-340	ATR-42	None
Major out-of-production models to be replaced.	B-99	Nord-262 DC-3 [1]	None	Visc-700 M-404 DC-4 [1] Convairs [1] C-46 [1]	DC-6 [1] Heralds YS-11 FH-227 [2]

[1] U.S. manufacture.

[2] Joint U.S. and foreign program.

Source: SRI International (1981).

The major foreign aircraft manufacturers are almost all strongly supported by their governments in one way or another. They are striving to greatly widen their market shares in the United States and worldwide in the face of existing dominant market positions and productivity advantages of the U.S. aircraft industry. Foreign governments are making a determined effort to overcome these obstacles by giving their manufacturers overwhelming financial advantages through direct financial subsidies, government equity investments, low-interest loans, forgiveable loans, loan guarantees and low-interest customer loans (7.5–12 percent). The problem for U.S. aircraft manufacturers is that of being able retain their market shares, conduct R&D for the future, and make a profit in a situation where foreign countries are willing to take on substantial overall losses on the aircraft and financing packages that they offer.

It would be a grave mistake to vainly attribute the progress of European aviation to use of U.S. technology. The Europeans have had as long a history in aviation as the United States. They have developed substantial capabilities on their own. The European Concorde has no U.S. supersonic transport counterpart. The possibility that they may have shared in U.S. research results and technology in greater proportion than we have utilized the results of their work is not nearly as important to the relative progress we are witnessing as is the large investments that the governments of these nations are putting into their aeronautics industries. Trying to lock up our aeronautics technology completely at this point will do little to stem the tide. Reasonable controls on technology transfer to foreign nations, seem warranted, particularly for communist nations. There should be reciprocal agreements for trading technology and for mutually productive joint program. Joint aircraft development programs should not be discouraged—it is a game that the U.S. also can play to advantage. The U.S. can likewise restrict U.S. sales of foreign aircraft unless there is U.S. participation in the development, manufacturing, and sales of foreign aircraft. This would only be appropriate for nations that apply such restrictions to our aircraft. The U.S. Government should become a partner in industry's efforts to cope with foreign government involvement in commercial aviation. However, we should recognize that there is nothing fundamentally wrong with any government attempting to advance its aviation industry. Many foreign governments simply appreciate the benefits that this industry has brought to our country.

IMPLICATIONS OF FUTURE CHALLENGES

The basic implication is that foreign competition is not only rapidly moving into a position to challenge the American aircraft industry in almost all commercial areas in aeronautics—but that foreign investments in this industry and the resultant rates of their progress have been far greater than our own. If they maintain their current rates of progress and we do no more than we have been doing—then foreign nations will surpass the United States, ending our world leadership position in aeronautics. The evidence warrants serious concern over the relative momentum of foreign aircraft industries. Market sales have just begun to reflect the gravity of the situation since about 1980, but the next five years will bring shocking news of penetration of the aviation markets by foreign countries. The great imbalance in the interest that the U.S. Government has reflected in fostering our aeronautics industry over the last decade relative to the strong determination shown in foreign capitals is the root cause of these dramatic changes. Even manufacturers in the United States are tapping foreign-government capital markets for support—while giving up potential market shares, aircraft manufacturing (U.S. jobs), and a certain amount of technology. Examples are: Lear Fan, the Saab-Fairchild SF-340, and more recently a Cessna-Reims business turbo-prop aircraft. The fact is that the only U.S. civil aircraft development programs receiving any direct government financial assistance are joint programs supported by foreign governments.

The U.S. Government's response to growing competition in aeronautics from foreign countries must be comprehensive and coordinated. International competition in aeronautics will be good for world economic development because it will stimulate aeronautical advances that will improve worldwide transportation. Still, the U.S. Government must respond to aggressive foreign government support for their aeronautics industries in order to balance the scales for U.S. manufacturers. The U.S. Government may provide such support as: financial assistance for aircraft development programs, increased research support through NASA, financial support, loan assistance, better negotiated trade agreements, coordinated trade offsets relative to other government-to-government programs such as military defense and, perhaps, assistance to U.S. airlines using aircraft manufactured in the U.S.

Government efforts to support the U.S. aeronautics industry should be a clear and balanced program. Perhaps the Department of Commerce or the Department of Transportation could play the primary role in working out a fully integrated program and monitoring financial assistance. Direct financial assistance to U.S. industry in civil aircraft development programs is far preferable to government-directed development programs for civil aircraft through an agency such as NASA. NASA will have a tendency to define the products, run the development programs, and interject its own engineering and business judgments in place of more experienced expertise available in industry. Private industry has a far better understanding of civil aircraft designs, manufacturing requirements, service needs, and their commercial markets than any government agency. NASA does not have a profit motive, and this would make it ineffective as a commercial product development agency.

The NASA situation relative to civil aircraft development is not at all similar to the DoD position relative to military aircraft development. The military services define, fund, and technically monitor military aircraft development programs. However, the military services are procuring aircraft for their own uses—for which they are the best available sources of knowledge and experience. The same is not true for any government agency relative to commercial civil aircraft development programs.

Hence, the Federal Government's involvement in commercial development programs and sales must be far more remote than for military development programs, in order to allow civil manufacturers the latitude they need to control their own programs to achieve success in the commercial market place. The more NASA diverts its attention to pursue large programs for systems, development, and operational problems in aeronautics the greater the detriment to important, creative, NASA research.

Aeronautical applied research should be greatly expanded in NASA in order to reestablish our nation's superiority in aeronautics. We have not been pressing forward nearly hard enough in pursuing new theories, systematically expanding our data base for advanced aircraft designs and developing new design innovations. NASA's aeronautical research efforts have been too meager and, at times, have been diverted into other areas. Strengthening NASA's aeronautical research should be one of the U.S. Government's major thrusts to advance this nation's position in aeronautics.

Question. Could you please elaborate on your program involving many non-aerospace corporations in exposure to NASA-developed technology?

Answer. We enclose herewith a reprint "Industrial Giants Offered NASA Space Education," reprinted from the Journal of Commerce (International Edition), January 18, 1982. This reprint describes the program in some detail. We would be pleased to provide any further information upon request.

[From the Journal of Commerce, Jan., 18, 1982]

INDUSTRIAL GIANTS OFFERED NASA SPACE EDUCATION

(By Dan McHugh)

For the first time, after trying many different approaches, the U.S. National Aeronautics and Space Administration seems to have finally found a way of convincingly communicating to the commercial mainstream of the American economy the unique value of the space agency as a systematic source for marketable new technology.

Despite intense budgetary pressure on its traditional "technology utilization" program, NASA is evidencing its earnestness by advancing small but significant funding for a new "technology-transfer" concept specifically designed to target the industrial leaders of the U.S. business community, particularly the top R&D decision makers from non-aerospace companies on the "Fortune 500" list.

Known as the NASA/AIAA Corporate Associates Program, the new strategy emphasizes face-to-face exchange and adds the aspect of NASA's long established commitment to "spin off" secondary uses of its technology.

The new policy was developed for the space agency by the American Institute of Aeronautics and Astronautics, the chief national organization of aerospace professionals, and, if successful, may become a model for other research agencies to follow.

Already six industrial giants, including John Deere & Co., A.E. Staley Inco. Sohio, Exxon and Eaton, have become sufficiently intrigued with NASA capabilities, revealed through the program, to contract with NASA and AIAA for tens of thousands of dollars in consultation and other reimbursable services.

They are primarily interested in getting a deeper look at certain NASA research specialties in materials science, especially relating to plastics and metals, as well as advanced industrial instruments or new processing and fabricating technology.

Through a series of exclusive, executive siminars, the non-profit AIAA helps bring together high-level R&D decision makers from the largest American corporations with their NASA counterparts.

Every two months or so, groups of 50 to 100 of the "Fortune 500" businessmen, often vice presidents or general managers of R&D, meet with NASA's top scientists, engineers and managers, the key people who are responsible for the agency's cutting-edge work in materials and systems research, design, production and testing.

The exchanges take place at one or another of the eight major NASA research centers around the country. Executives from some 125 of the leading 500 firms already have attended 11 of the day tours held at the space agency's far-flung facilities in Maryland, Virginia, Alabama, Ohio, California, Florida, Texas as well as Washington, D.C.

On a typical tour, after a preliminary briefing, the private sector visitors break up into small groups and go into the selected labs and shops where NASA's treasures are created. After listening to a research topic presentation from a leading NASA researcher, delivered directly from his workbench or lab table, the industry group members get down to business by engaging in an uninhibited dialogue with the NASA people and even their fellow corporate peers.

Often, much to the surprise of both parties, mutual areas of concern and interest quickly emerge in regard to common problems that would not have been readily apparent through a mere perusal of NASA's voluminous abstract literature. All attest that there is just no subsitute for directly eyeballing, and even handling, a fellow expert's work to spark ideas and discussion.

While a private executive may have been motivated to participate by some perceived relevance to his own work of only a few, or even just one, of the approximately eight research topics on the preliminary agenda, part of the adventure of the program is finding those unexpected connections between the government research and the company's own that may not be obvious initially.

John Deere & Co., and other metal fabricators, found that the "stress analyzer," which NASA uses to test the single bolt that binds the shuttle orbiter to its fuel-tank, could be used to non-destructively test critical bolt assemblies in almost any kind of machinery or structure more cheaply than previous methods.

Exxon Enterprises and other energy companies discovered that explosive joining techniques that evolved from NASA's work on emergency egress hatches for space and aircraft have been found useful by the Canadian Atomic Energy Authority for quick, but perfect, cold weld repairs to pipes in hard-to-get-at places in nuclear plants.

And the Ball Corp. has identified new industrial uses for many of the greases, sealants and lubricants which NASA originally developed for space missions.

Confrontation with real objects, whether instruments or material samples, without the obscuring filter of in-house jargon in the printed literature, is often necessary to trigger the first recognition of relevance. Other insights are mentally filed away for future reference.

However, the visitors do not go away empty-handed. By the end of the day they have accumulated a bulging briefcase full of appropriate technical briefs and reports to reinforce their direct experience. At a final gathering, they can ask any of the NASA researchers questions that may have occured to them after they—had moved on to the next stop.

Beyond this, arrangements are made for specific follow-up actions, ranging from a phone call to full-scale consultations.

The Corporate Associate Program participants have consistently demonstrated their satisfaction with this approach to the technology transfer problem by coming back repeatedly for new visits.

The learning process is not all one way. The NASA people, in turn, expect to become much more aware of the true state-of-the-art of certain private sector research specializations that they might otherwise miss, due to the proprietary discretion that usually blankets such matters.

According to Tom Hartford, the AIAA official who originated, and still manages the program, nearly two decades of individual espsodic successes in transferring NASA's technology into new commercial products and services have not translated into a systematic self-sustaining process enabling U.S. industry to meet new economic challenges from Japan and Europe. There has been no learning curve for the economy as a whole.

Most of all the NASA potential has been only marginally visible to the mainstream corporate heavyweights who have the required breadth of commercial experience and in-depth R&D capability to routinely absorb advanced technology.

In the past, NASA's give and take working partnership with U.S. aircraft manufacturers has been recognized as the key element in America's historical domination of the world aviation market. However, the space researchers have not been able to establish a similar relationship with general industrial organizations because, until now, respect for their specialized aerospace expertise did not enhance the credibility of the commercial potential of their generic reserach base.

The moon mission stigma, applied even in areas such as materials science, for example.

It is for this reason that the Corporate Associates siminar series is deliberately focused on the leading 500 corporations because they represent $16.5 trillion in collective wealth, or more than half the U.S. GNP. The second 500 down the Fortune list represent only about $120 billion, or less than a tenth the financial clout of the front runners.

Ms. **Lane**. Thank you. We will be submitting questions for the record. The hearing is adjourned.

[Whereupon, at 10:48 o'clock a.m., the subcommittee adjourned.]

NASA AUTHORIZATION FOR FISCAL YEAR 1983

THURSDAY, APRIL 1, 1982

U.S. Senate,
Committee on Commerce, Science, and Transportation,
Subcommittee on Science, Technology, and Space,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:47 a.m., in room 235, Russell Senate Office Building, Hon. Harrison Schmitt (chairman of the subcommittee) presiding.

OPENING STATEMENT BY SENATOR SCHMITT

Senator Schmitt. The hearing will come to order.

During the decade of the 1970's the price of aviation fuel increased by a factor of 10 and the effects on airline operating costs as well as on the Department of Defense fuel budget has been disastrous. These price increases contribute directly to the current financial difficulties of U.S. airlines, as is shown by the recent furloughing of thousands of airline employees.

Had this committee, under the leadership of the distinguished Senator from Nevada, who is here with us this morning, not passed the airline deregulation bill, I think we would have seen even further extreme difficulties in the airline industry. Even my good friend Frank Borman, who opposed us in that effort, now admits, Senator Cannon, the airline deregulation was the best thing that ever happened to Eastern.

In order to reduce the operating costs of aircraft as well as capital costs of new transport aircraft, NASA initiated a number of programs, including the laminar flow control program, energy-efficient transport, the energy-efficient engine, the composite primary aircraft structures, and the advanced turboprop programs.

The overall objectives of these NASA programs are to reduce the fuel consumption of transport aircraft by 30 percent by the late 1980's. Some people in the aircraft industry believe that these savings could be doubled by the 1990's, and yet support for these programs within NASA and, to some degree, within the aviation community itself, has been drastically reduced during the fiscal years 1982 and 1983 periods.

Another major problem facing the U.S. aircraft industry is competition from other nations. The U.S. companies have been the leading suppliers of commercial aircraft to the world for decades, not in small part because of the NACA and NASA efforts in that period of time. In recent years, these suppliers have been challenged by European consortia and the Japanese, as well as other nations such as Brazil, who have been encouraged and strongly supported by their governments.

There is no question that the financing of new ventures is as critical a problem for our domestic industry as funding for advanced research and development activities. In terms of dollars it is a much greater problem. So far, the products of these other nations and consortia, such as the wide body and fuel-efficient aircraft, have made serious inroads into what was almost an exclusive American market.

The stakes in this game are high. For example, the U.S. commercial aircraft industry exported $35 billion in net sales during the past 10 years. This represented over 1 million jobs involving about 10,000 companies of all sizes in the United States.

The potential world market for future sales is projected to be $10 billion per year in 1980 dollars for the decade of the 1980's. If the European aircraft consortia and others are successful in their penetration of this market, as they may very well be, there could be hundreds of thousands fewer U.S. jobs in this industry and a further increase in the negative balance of payments that we have already of billions of dollars per year.

The NASA budget request severely curtails a highly successful systems technology program. There is a tremendous concern about the potential disasterous effects of this action on the health of one of our strongest industries. We intend to closely examine the consequences of the termination of current programs and the elimination of new ones before this Nation heads down an irreversible path.

The relationship between the aeronautics industry and the Government has traditionally been a strong and vital one. It is precisely this strength which has made this country a world leader in the aircraft market, and it is this strength which we must preserve.

I should add, that in spite of assurances by the Department of Defense, that the essential aeronautic programs are being continued either by NASA or by the Department of Defense, I have a tremendous concern. I also know that this concern is shared by other members of this committee, and that it is only the defense-related aeronautics programs which are being continued while those related to the health and strength of our domestic economy are being curtailed or terminated.

Some of these programs have essentially reached the end of their useful or planned life and we must take that into account as we examine this budget. Overall, as many have said and as I have felt for some time, I think we are in a period of unacceptable decline in the research and technology efforts applied to aviation.

Senator Cannon.

OPENING STATEMENT BY SENATOR CANNON

Senator CANNON. During this subcommittee's hearings on February 23, you and I carried on extensive discussions with the NASA Administrator relating to the agency's fiscal year 1982 operating plan. We shared a common concern that the agency had failed to respect or conform to the will and intent of Congress with respect particularly to its allocation of funds authorized and appropriated for certain aeronautics programs.

I am sure we both understand that the action of the agency was dictated by OMB directive. That in turn was based on OMB's philosophical thesis to the effect that so much of aeronautic technology development as it extends to validation and demonstration of advanced technology is not the proper role of NASA and would no longer be funded by the Federal Government.

Although that same OMB directive is at work in the agency's fiscal year 1983 budget now before us for evaluation, I see little point in harassing NASA's witnesses today on the same conflict between congressional policy and OMB's philosophy.

Mr. Chairman, you have brought together today a broad range of outstanding experts involved in many aspects of aviation. They can address the aviation industry's contribution to the Nation's trade balance, its financial standing, its need for technology systems development to cope with international competition, and its need for advanced technology for the economic health of the airline industry.

By devoting as much of our time as possible to hearing and discussing their testimony, our committee can reassess and either reaffirm or alter its past policy. If we reaffirm, Mr. Chairman, it then becomes our duty to reflect that in our authorization both in dollars and in programs in such a manner that our intent can in no way be mistaken.

There is little need for me to restate my views on the vital role of NASA's aeronautical systems technology programs in our Nation's economy. They have been amply communicated in a number of my statements throughout the first session of this Congress.

Let us, rather, hear from those directly involved how our aviation leadership contributed to our trade balance, to our domestic employment, to our airline industry, and its hundreds of millions of users. Let us hear from these witnesses the likely effect on those values if we fail to continue that aviation technological leadership.

In closing, Mr. Chairman, I commend you on your determination to explore these matters in open hearing and to provide this wide range of established experts to inform us on the underlying facts.

Thank you, Mr. Chairman.

Senator SCHMITT. Thank you, Senator. As you and I both know, when we look back on the history of U.S. technology to those areas of research and technology development that have sustained major portions of our economy for a long period of time, we find two principal examples.

One is agriculture. Through the land grant college system and through the Extension Service, agricultural technology has been sustained and improved to the point where we literally can feed the world.

The other example, of course, is aeronautic technology which, over an even longer period of time, has caused the U.S. aircraft industry to be second to none in the world. What we are concerned about is the threat which that industry now faces, not just from foreign competition, the more competition the better, but from a lack of interest on the part of the Federal Government in sustaining the technology base which is so essential to a healthy and vibrant economy in that area.

Our first witness is Dr. Jack Kerrebrock, Associate Administrator, Office of Aeronautics and Space Technology, with NASA. Doctor, it is good to have you with us, and if you would introduce your colleagues, as appropriate, you may proceed with your statement. I hope you will summarize your statement. The entire statement will be included in the record.

STATEMENT OF DR. JACK L. KERREBROCK, ASSOCIATE ADMINISTRATOR, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NASA, ACCOMPANIED BY C. ROBERT NYSMITH, ACTING DEPUTY ASSOCIATE ADMINISTRATOR

Dr. KERREBROCK. Thank you, Mr. Chairman and Senator Cannon. I am pleased to be here today representing the Office of Aeronautics and Space Technology to present NASA's proposed fiscal year 1983 aeronautical research and technology program and budget.

I am accompanied by my Acting Deputy, Mr. C. Robert Nysmith, as well as my Division Directors who will assist me in answering any detailed questions. I would like to introduce them, if I may. Mr. Gerald Kayen is Deputy Director of the Aeronautical Systems Division; Dr. Ray Colladay is Director of the Research and Technology Division; Mr. Fred Povinelli is Director of our Institutional and Program Support Division; Mr. William Peterson is Director of the Resources and Management Systems Division; and Mr. Frank Penaranda is Director of our Facilities Office. We are also pleased to have here this morning Dr. Donald Hearth, who is the Director of the Langley Research Center.

Senator SCHMITT. It is good to see Dr. Hearth again.

Dr. KERREBROCK. I have a formal statement which describes our fiscal year 1983 budget request and explains in considerable detail some of the major accomplishments and plans of our aeronautics program. With your permission, I would like to submit this written statement for the record and devote my oral presentation to a general characterization of the program.

Senator SCHMITT. Without objection that will be done.

Dr. KERREBROCK. As indicated on the first chart [fig. 1], our requested fiscal year 1983 research and development [R. & D.] budget totals $232 million, $1 million less than our current fiscal year 1982 figure. It consists of a slightly increased research and technology [R. & T.] base program and a reduced systems technology element. The R. & T. base budget of $182 million continues to support the advancement of critical technologies and basic understanding in the major aeronautical disciplines of aerodynamics, propulsion, materials and structures, guidance and controls, and human factors. The budget request for systems technology for fiscal year 1983 has been reduced to $50 million, a level considerably below the budget estimate for fiscal year 1982. Systems technology efforts for rotorcraft and high-speed aircraft have been retained because of their importance to future military systems. We have had to eliminate certain systems-related activities in support of commercial aviation needs. We have, however, included certain discipline-related activities within the R. & T. base to compensate for some of the more critical systems reductions.

Our activities can be divided into three major categories, as shown on figure 2. Disciplinary research and technology are long-term activities which are relatively basic and broadly applicable to all vehicle-classes and account for 62 percent of the total budget. These efforts provide for the generation of a technology base for future civil and military aircraft including research applicable to general aviation and transport aircraft. The work capitalizes on a strong blending of in-house NASA facilities and expertise with university and industrial research capabilities. The vehicle-class research and technology effort proposed for fiscal year 1983 is divided about evenly between the low-speed and high-speed aircraft classes. In both cases, the systems technologies are strongly relevant to military aeronautics but also are largely applicable to civil aeronautics. This work will be principally in the rotorcraft and high-performance aircraft areas.

As a result of the reorganization which was implemented last December at NASA headquarters, the Ames, Langley, and Lewis Research Centers now report to my office. In coordination with the three Center directors, my office formulates and manages the construction of facilities and research and program management budgets as well as the research and development element.

The magnitude of the added institutional responsibility of the three research Centers and their total population of 7,345 civil service positions is compared to my continuing responsibility for management of the Aeronautics and Space Technology R. & D. program in figure 5. There is $485 million, or nearly 65 percent of the OAST institutional and R. & D. budgets, being applied directly to aeronautics research and technology. The R. & P.M. budget applied to technology supports 3,764 direct civil service positions, almost all of which are located at the three OAST Centers—Lewis, Langley, and Ames.

Figure 3 indicates the technical emphases at each research center and depicts the distributions of the proposed fiscal year 1983 R. & D. budget by Center. The bulk of the aeronautics program will be conducted at the OAST Centers—Ames, Langley, and Lewis. Each of these establishments represents a center of excellence in the technical disciplines shown on the figure. These capabilities have taken decades to develop. They include expert scientists and engineers, as well as unique facilities which complement the resources of industry, universities, and the military to form an national aeronautical research and technology capability. We place a high priority on its preservation, development, and efficient utilization for both the civil and military sectors of the U.S. aviation industry. Maintaining these Research Centers in positions of undisputed excellence requires the introduction of new facility capabilities, improving the productivity and capacity of operating facilities, and improving computational capabilities as well as continually sharpening and modernizing the technical skills of the work force.

At the Langley Research Center, two unique facilities will begin operation during fiscal year 1983. The national transonic facility will be the world's most advanced high Reynold's number facility for simulating the effects of full-scale flight Reynold's numbers on wind tunnel models. The new Avionics Integrated Research Laboratory, or Airlab, will be the most advanced laboratory in the country for research on fault-tolerant electronic control systems. At the Ames Research Center, the manned vehicle systems research facility will also be operational in fiscal year 1983. This new aviation system simulation facility will provide this country with its most sophisticated tool for critical human factors research. At Langley, construction of facility funds are being requested in fiscal year 1983 to increase the density range of the transonic dynamics tunnel by 50 percent to enable simulation of key aeroelastic parameters for current and future aircraft designs. The 4- by 7-meter low-speed tunnel will also be modified to increase its operational efficiency and productivity.

Funds are also being requested in fiscal year 1983 to improve the engine research facility at the Lewis Research Center by adding a new air compressor to replace and supplement the present aging machine. These unique national aeronautical capabilities developed by NACA and now NASA over the last half century are widely utilized to perform research in cooperation with other Federal agencies. For example, NASA works very closely with the FAA to provide the fundamental technology to improve the efficiency and safety of the national air transportation system, as well as the safety of general aviation aircraft, rotorcraft, and transport aircraft.

A substantial proportion of the low-speed aircraft technology program is conducted in close cooperation with the Army. Also, several elements of the program are conducted in cooperation with the Navy and the Defense Advanced Research Projects Agency, DARPA. The military activity is directed toward long-term research on rotor systems and advanced rotorcraft propulsion systems. NASA also works very closely with DARPA, the Air Force, and the Navy in research and technology efforts related to high-speed aircraft. New concepts in aerodynamics, flight dynamics and controls, aeroelasticity, propulsion and propulsion/airframe integration are investigated for application to strategic and tactical aircraft, vertical-takeoff-and-landing aircraft and missiles.

In summary, while there are some technology challenges that will have to go unmet because of budgetary constraints, we feel the fiscal year 1983 budget request represents a valuable aeronautics program. We will maintain the capability to respond to increased systems technology needs in the future and will continue to advance the technology base in all key aeronautical disciplines for both military and civil applications. With the strong support of this committee, Mr. Chairman, over the years we have built an aeronautical research program of which we can all be proud. We intend to sustain this effort to the best of our ability to meet as many of your and our objectives as possible in order to preserve our leadership in world aviation.

Mr. Chairman, this concludes my overview. I would be pleased at this time to respond to any questions that you may have.

Senator SCHMITT. Thank you, doctor.

Is NASA involved in any of the current FAA studies related to either icing problems or the new air traffic control system?

Dr. KERREBROCK. Yes, sir, we are conducting basic research, for example, in the air traffic control area. We are operating a facility called the Terminal Configured Vehicle out of Langley, which is developing cockpit instrumentation and air traffic control strategies which will be incorporated in the air traffic control system at some time.

Senator SCHMITT. Could you provide us for the record a brief summary of that effort?

Dr. KERREBROCK. We certainly will.

[The following information was subsequently received for the record:]

Although there are a number of long-standing research areas in which the FAA and NASA are cooperating under both formal and informal joint agreements, this summary concerns NASA activities in only those area recently identified by the FAA as of immediate utility to them.

Microwave Landing System (MLS).—Although development of MLS ground equipment is nearly complete, additional work will be conducted on procedures and operational guidelines for its use, particularly in more complex terminal procedures. NASA will provide a uniquely equipped research aircraft and research personnel familiar with the MLS to work in cooperation with FAA. Advanced cockpit displays and various airborne MLS implementation concepts will be used for exploiting the full MLS approach and landing capabilities under adverse weather conditions including wind shear.

Integrated Flow Management.—Under a joint agreement with FAA, NASA will develop and use its analytical capability, simulation techniques, and flight test facilities to address technological and procedural problems associated with Integrated Flow Management. FAA will be responsible for eventual selection of techniques to implement the strategies which they deem most favorable from an Air Traffic Control System standpoint.

"Human Being in the System" Studies.—NASA will conduct studies on: cockpit workload assessment techniques; optimal pilot/controller interaction in the evolving National Airspace System; complacency, inattention, boredom in the cockpit (this will connect with FAA studies on controller interaction with automatic system); computer-aided decisionmaking; and effectiveness of various concepts for alert and warning systems. It will also provide for the joint establishment with the FAA of a Human Factors data base for air and ground system designers.

Helicopter Program Activities.—Conduct flight evaluation of the use of the Department of Defense satellite-based NAVSTAR Global Positioning System signals in a differential mode for precision landing approaches by rotorcraft.

Provide single pilot operationg capability to operate into and out of remote sites offshore and onshore with onboard guidance and navigation systems. Flight activities have focused on the use of an airborne radar as a landing guidance system in conjuction with simple beacons and passive reflectors at the landing sites.

Develop the technology necessary for the accurate prediction of the noise characteristics of new helicopter designs. This involves a coordinated effort between NASA, industry, the Army, and the FAA.

Study possible improvements to the National Airspace System so as to permit helicopters to employ their unique capabilities to the maximum practical extent.

Advanced Navigation System.—NASA has conducted studies indentifying the potential civil uses of the DOD satellite-based NAVSTAR Global Positioning System, examining the technological and testing needs of the potential civil users, and formulating low cost concepts for civil receivers. This work is being carried out under an existing interagency agreement between NASA and FAA.

Conducting studies of the potential of weather penetrating sensors (such as infrared and imaging radar) for special low-visibility applications.

Support for Vertical Separation Standards.—Using the instrumentation available at the NASA Wallops Flight Facility, NASA will participate with FAA in a significant data gathering activity dealing with the performance of aircraft in the high-altitude environment along airways in order to validate and lay the basis for improving separation standards and performance assessment. Utilization and correlation of the data base collected through NASA's VGH (velocity, acceleration and altitude) instrumentation program, to supprt vertical separation research on atomospheric variations due to mountain waves and weather front discontinuities, will be continued.

Wake Vortex Alleviations.—NASA's present approach to the thorny wake vortex alleviation problem is to explore the fundamental physics of aircraft wakes. These investigations will provide the technology necessary to develop advanced alleviations methods.

Mode S Data Link.—The FAA has completed the development of the discrete addressing function of the Air Traffic Control Radar Beacon System, called Mode S, which will provide improvement in the air traffic control secondary radar surveillance, and will also provide the basis for air traffic control data links which serves as the communications medium for the Traffic Alert and Collision Avoidance System (TCAS) and communications between the aircraft and the ground. The introduction of the data link services utilizing Mode S will require careful selection of prospective data link services to provide needed services to other aircraft. FAA has asked NASA to participate in a joint activity with the FAA Technical Center on integration of the data links with other cockpit functions and to evaluate their human factors involved in the cockpit data link displays and interfacing techniques.

Cockpit Display of Traffic Information (CDTI).—A number of uses of CDTI, which gives the pilot pictorial information on traffic of concern, have been postulated. NASA and FAA are conducting a joint program involving simulations, flight evaluation, and human factor studies at Ames Research Center, and FAA Technical Center to provide a data base to answer fundamental safety questions needed for certification and capacity questions affecting the air traffic control system design.

Traffic Alert and Collision Avoidance System (TCAS.—NASA will make antenna pattern measurements on scale models of aircraft to determine and airframe effects on angle-of-arrival measurement accuracy of the directional receiver and interrogration capabilities which permits TCAS to operate in high density areas.

Aircraft Performance on the Runway.—The relationship between the pilot, aircraft, and non-standard runway conditions has been the subject of a long-term research program at Langley Research Center utilizing several unique facilities. These include the Landing Loads Track, several ground test vehicles, a ground handling simulator, and specially constructed of runways at Wallops Flight Facility. Research includes the evaluation of current transport anti-skid braking system on wet runways, development of advanced braking system, and development of advanced tires to resist blowout and temperature buildup.

Highly Reliable Advanced Integrated Flight Systems.—Activities will define functional requirements performance criteria for flight systems and displays of the future with which the pilot can safely and effectively operate in the evolving National Airspace System to perform more efficient flight with respect to fuel, airspace, and time; to increase traffic flow capacity; to improve the operational capability in adverse weather; and to reduce noise impact on the ground. Understanding the capabilities and constraints of airplane system that interface with other elements of the air traffic control system must be factored into the design of the National Airspace System. This effort encompasses also the impact of electromagnetic compatibility problems, lighting, and other transients on the airborne systems. Research on fault-tolerant controls which permit flight-crucial controls to function at full performance even with multiple failures in elements of the hardware of software will be expended in FY 1983 as the new Avionics Integration Research Laboratory (AIRLAB) becomes operational.

These activities, highlighted by the FAA, fit NASA's role in research on airplane systems that interface with other elements of the ATC system. Capabilities of airplane systems and constraints must be factored into the design of the ATC system. Understanding of these capabilities and constraints, their significance and acceptance in promoting safe, conflict-free, fuel-efficient flight depends upon thorough analysis and validations which are major thrusts of NASA's technology program. This program is needed to bridge the gap between technological requirements that can be satisfied solely through ground facilities and those best satisfied by the airplane.

Icing Program.—In 1981, after NASA's major icing program initiation of 1978, NASA and the FAA enter into an interagency agreement in which NASA is conducting icing research of interest to the FAA in a number of areas to help conduct the research, the FAA is contributing approximately 10 percent of the total program funding of approximately 1.1 million per year. The major elements of the icing program are:

Analytical Modeling.—Update the design data base and develop computer codes or aircraft design in icing conditions and for use by the FAA in icing certification. This includes water droplet trajectory and impingement codes, ice accretion and the resultant aerodynamic degradation, and flight test validation of all codes.

Atmospheric Icing Criteria.—NASA will participate and support icing cloud data acquisition and analysis which will enable the FAA to validate Federal Aviation Regulation Part 25, Appendix C, the atmospheric icing criteria. A data base will be developed for freezing rain and drizzle, snow, and mixed conditions with a goal of including such conditions in the certification criteria.

Ice Protection Technology (anti-icing/de-icing).—Light-weight, low-power consumption and hopefully, low-cost ice protection systems are being investigated. Included are electro-magnetic impuse systems, improved pneumatic boots and glycol systems, and possibly a microwave concept. Such systems are being investigated for use on rotorcraft, general aviation, commuters and commerical aircraft.

Icing Instrumentations.—Instrumentation to measure, reliably and accurately, cloud properties, e.g., liquid water content and water droplet diameter are being evaluated by NASA. The accuracy of new and old instruments and standard calibration techniques are being investigated in the NASA Lewis Icing Research Tunnel (IRT). NASA also plans to conduct research on how such instruments, normally used on research tasks, can be used on board aircraft to transmit icing data to the FAA and the National Weather Service. A novel microwave instrument is currently under development by NASA to detect ice accumulation on an aircraft and measure its thickness and growth rates.

Pilot Training.—NASA and the FAA Technical Center, plan to collaborate with industry and operators to develop pilot training aid (such as movies, videotapes, and proposed advisory information) for dealing with flight in icing conditions. From the analytical methods and experimental design data bases that will be developed as part of this joint NASA/FAA program, consideration will be given to use of aircraft flight training simulators that will assist pilots in learning to cope with various icing scenaries. This program is jointly funded, primarily by the FAA.

Aircraft Icing Flight Program.—It is essential to validate analytical methods, icing instrumentation, and icing simulation facilities via actual flight tests in simulated and natural icing conditions. To this end, NASA has provided a dedicated aircraft, pilots, and maintenance personnel for icing flight test work. The first flight of this icing flight aircraft took place on March 12, 1982, and was the first NASA aircraft icing research mission flown since 1957.

Senator SCHMITT. And what about the icing characteristics of aircraft?

Dr. KERREBROCK. For a very long time we have had a fundamental program of research on icing at the Lewis Research Center. In fact, we have the dominant icing facility in the country at our LERC icing research facility. It has provided a great deal of fundamental information on icing characteristics for all kinds of aircraft, including rotorcraft.

Senator SCHMITT. Have you participated in the Air Florida investigation?

Dr. KERREBROCK. No; we have not been directly involved in that investigation.

Senator SCHMITT. Is there any reason for that? Is it just that you were not invited or you do not have anything to contribute in spite of the research facility?

Dr. KERREBROCK. I think the reason is that the questions that are involved are not ones of basics but rather of operational procedures and so forth.

Senator SCHMITT. We may have some questions for you for the record on that. I am not sure how you separate the two in that kind of a situation.

Dr. KERREBROCK. Perhaps I could elaborate just slightly to say that the source of the difficulty in that accident seems to have been procedures in deicing the aircraft.

Senator SCHMITT. Also, pilot recognition of a problem.

Dr. KERREBROCK. Yes, sir; but not a lack of basic understanding of the effect of icing on the performance of the aircraft per se, which would be the kind of work we would do.

Senator SCHMITT. It does not do you much good to have all that information about the effect of icing on the aircraft if the crew is not sufficiently alert to the problem, and if they continue to attempt to take off.

Dr. KERREBROCK. I agree.

Senator SCHMITT. Indicators of the extent of the icing problem either were ignored, or were inadequate, or both.

Dr. KERREBROCK. Yes; I agree with that.

Senator SCHMITT. If you have any further thoughts on that, we would like, for the record how might the information that NASA currently has or could gain in their research facilities contribute to better warning systems or indications of an ice buildup that would significantly affect aircraft performance.

Dr. KERREBROCK. We will provide that for the record.

[The following information was subsequently received for the record:]

As mentioned before, NASA is conducting tests on a microwave instrument which will detect the presence of ice on aircraft surfaces and measure its thickness and rate of growth. Studies on this instrument are being conducted in NASA's Icing Research Tunnel (IRT) with the instrument installed on an actual airfoil section. Results to date look promising and NASA expects to continue research on this new instrument concept.

NASA is also conducting ice accretion studies on airfoils in the IRT and in icing flight tests. This includes the development of associated computer models which will predict the aerodynamic degradation of lift and drag which affect aircraft performance in icing conditions. Such data should be useful to pilots to make timely decisions on aircraft operating parameters prior to take-off or in flight. This data is also required in the FAA's advanced flight training simulator program.

Senator SCHMITT. We understand the philosophy that technology demonstration programs will be the responsibility of industry. Specifically what technology demonstration projects have been terminated in fiscal year 1982 and zeroed for fiscal year 1983?

Dr. KERREBROCK. There are a series of programs which have been terminated or reduced in fiscal year 1983 as a result of the budget actions. As I mentioned, the systems technology programs which have been allowed are those which have a strong DOD relationship. These are in low- and high-speed aircraft and together total $50 million. The ones which we have not been able to continue are those with what was judged to be primarily a civil orientation in the categories of transport aircraft, advanced propulsion systems, and general aviation. I would like to make the point that none of these activities are really demonstration programs. They are what we prefer to call systems research programs directed at advancing the state of the technology one stage beyond the basic level, but by no means do they go all the way to full-scale development.

Senator SCHMITT. Well, I understand that and you understand that, but it seems that OMB does not understand that. Why is that a problem?

Dr. KERREBROCK. I think the basic issue is where in the spectrum from basic research to full-scale development the line should be drawn for Government funding.

Senator SCHMITT. NASA has not traditionally, and right now I cannot think of an example in the aircraft area, done anything that the industry would really call demonstration, have they?

You have never built a prototype airplane and flown it?

Dr. KERREBROCK. There have been a few programs in the last few years which would be called demonstration; for example, the engine component improvement program, which was definitely improvement of production equipment. But they are the exception and in general I agree with you—they were not demonstration programs. They were more nearly systems research and systems technology, which are programs that are required to investigate the interaction between the elements of a system in order to assess the feasibility of new concepts and advanced concepts.

Senator SCHMITT. Thank you. Senator Cannon.

Senator CANNON. Thank you, Mr. Chairman.

On February 23, Jim Beggs said that he had not yet had any indication from industry as to whether they could or would pursue the systems technology programs now deleted from your fiscal year 1983 budget. Have you had any indication on that matter during the past few weeks?

Dr. KERREBROCK. No, sir. I do not believe the situation has changed.

Senator CANNON. What portion of the funding in your technology base is expended in industry research contracts versus the portion expended in systems technology programs?

Dr. KERREBROCK. I think that your question is which fraction in the research and technology base is expended in industry?

Senator CANNON. And which portion in the technology program.

Dr. KERREBROCK. About 39 percent is contracted in the R. & T. base in fiscal year 1982. Now some of that would be in academia and some in industry. The fraction was larger in the systems technology programs. It is, however, changing at the present time, and the part that is going out-of-house is going down. I think that for fiscal year 1983 it is about 35 percent.

I can in fact, give you the numbers rather precisely. In R. & T. base research in fiscal year 1983, it is 64 percent in-house at NASA, 21 percent in industry, and 14 percent in universities and colleges. Now, there is a shift there. In 1981, those numbers were 60 percent in-house, 23 percent in industry, 14 percent in universities and colleges. That is the aeronautical R. & T. base.

Senator CANNON. Well, now, would you agree that the real strength of the longstanding Government-industry collaboration resides in the execution of the system's technology programs?

Dr. KERREBROCK. I believe, sir, that a proper balance between the long-range R. & T. base activities and the systems research and technology programs is essential. We need both.

Senator CANNON. Well, but you are cutting back in the systems technology programs.

Dr. KERREBROCK. Yes, sir.

Senator CANNON. So if our committee, after reviewing the testimony from this hearing, determines to strengthen the systems technology programs, would you be free to offer your recommendations as to funding support for specific programs?

Dr. KERREBROCK. Yes, sir. I think we would.

Senator CANNON. Thank you, Mr. Chairman.

Senator SCHMITT. Thank you, Senator.

As a followup, do you think that the balance reflected in the 1983 budget is a better balance than what you had in fiscal years 1982 and 1981?

Dr. KERREBROCK. I believe that given the overall level of the aeronautics R. & T. program, in fiscal year 1983 the balance we have struck is reasonable. I believe that the systems technology programs——

Senator SCHMITT. Which means it was the only one you were allowed to strike. Is that correct?

Dr. KERREBROCK. Well, that is not quite true, Senator, because within the R. & T. base program we can redistribute the funding to different kinds of activities. We feel that a prime requisite at the present time is to maintain the competence of the research centers. That requires a certain level of support in the R. & T. base.

We also feel that we need to make better use of the facilities of NASA which requires funding from the R. & T. base at a certain level as well as from the systems technology program.

In balancing these requirements against the requirements and the real desire to continue contractual support for our external constituency—which I would like to emphasize is a very, very important part of the NASA R. & D. organization—we have tried to strike a reasonable balance and have arrived at the numbers that you see.

Senator SCHMITT. But that is the reason why you have seen a major shift in the relative distribution between in-house and out-of-house activities. It is because you are trying to better maintain utilization of the NASA facility base. Is that correct?

Dr. KERREBROCK. Yes, sir.

Senator SCHMITT. To do that you had to cut out the out-of-house activities or reduce them.

Dr. KERREBROCK. I would like to emphasize that a major impetus for the present budget was the allowance for a rather strong R. & T. base effort and systems technology effort, which is strongly supportive of the DOD. The combination of those two allowances led to the result that you see.

Senator SCHMITT. How much does DOD utilize of the NASA facility base?

Dr. KERREBROCK. Very, very extensively. The NASA facility base has been and is essential for every military airplane development.

Senator SCHMITT. What about the commercial sector?

Dr. KERREBROCK. It is also absolutely essential for every commercial development. The commercial aircraft companies do not have facilities which are comparable to the NASA facility.

Senator SCHMITT. Are those activities done on a reimbursable basis for DOD and the commercial sector?

Dr. KERREBROCK. No, sir. We do not charge DOD. We charge industry marginal costs.

Senator SCHMITT. Why shouldn't we charge DOD? Why should they get a free ride when you compare the size of their budget and what has been happening to the NASA aeronautical budget?

Dr. KERREBROCK. Historically, it has been.

Senator SCHMITT. I know what the history is, but history changes.

Dr. **Kerrebrock**. Yes, sir. I guess the only answer I could give you is that they both come out of the Federal budget.

Senator **Schmitt**. Sure they both come out of the Federal budget, but they are dealt with in different budget lines, let's face it. NASA is carrying DOD in their space and aeronautical development to a great degree in spite of DOD's arguments to the contrary. DOD has their own facilities, and they are also building the Vandenberg launch facility and you name it.

Nevertheless, those facilities would be useless without the base that NASA provides.

Dr. **Kerrebrock**. Yes, sir.

Senator **Schmitt**. Either in Shuttle development or, as you have indicated, in aeronautical facility development.

Dr. **Kerrebrock**. Yes, sir; but I would argue that it has been part of NASA's basic charter from the time it was founded in 1915 to support the military activities of the United States.

Senator **Schmitt**. I agree with that. I agree. I think it is an important part of the charter, but unfortunately another part of NASA's current charter is being depleted while at the same time you maintain that kind of level of support for DOD activities on a nonreimbursable basis.

Dr. **Kerrebrock**. Yes, sir.

Mr. **Nysmith**. Senator, may I make a point on the military support? There tends to be a perception that we do development testing. We are not really talking about that kind of work in the NASA facilities typically. It is research oriented toward military concepts, so we tend to trade off the gains we get from research on advanced concepts point of view and from that point of view it is to our advantage to actually be working on those military concepts. We get research knowledge out of that.

Senator **Schmitt**. I am not going to argue that point. I am sure you do. The military also gets advantages out of what NASA does in the commercial research area that is not directly tied to DOD.

The basic problem is that it is NASA's charter that is being violated by current budgetary constraints and it is not the Department of Defense's charter that is being violated. I think we have lost sight of what the basic functions of NASA are in aeronautics as well as in some space activities.

Is there a priority established in the use of facilities? Does DOD get first call even though the commercial sectors may have been there ahead of them?

Dr. **Kerrebrock**. Not quite. There is a system of allocation of the time and the facilities of NASA. I am sure you are aware that under the unitary wind tunnel plan DOD does have priority in some of the tunnels but not all of the tunnels. There is an attempt within NASA to properly allocate the resources for research for commercial aircraft testing and development and for military testing, development, and research.

Senator **Schmitt**. What is the waiting time or the delay required to get onto NASA facilities?

Dr. **Kerrebrock**. For the major facilities that are in great demand, it tends to be as long as 2 years.

Senator SCHMITT. Do you always have the commercial sector at the end of that line or does your allocation of priorities allow some interlacing of commercial and defense activities?

Dr. KERREBROCK. Yes, sir. To the best of my understanding, this is done on a technical basis insofar as possible. The question is asked: Which testing will contribute the most to the understanding of the aerodynamic phenomena?

Senator SCHMITT. Who makes that judgment?

Dr. KERREBROCK. The NASA center personnel.

Senator SCHMITT. Do they have advisory groups that assist them in that judgment or in the final analysis does the decision rest with the center directly?

Dr. KERREBROCK. We do not second-guess that decision at headquarters.

Senator SCHMITT. What is the name of your aeronautical advisory team?

Dr. KERREBROCK. We have more than one. We have an Aeronautics and Space Engineering Board which operates out of the Academy of Engineering and an Aeronautics Advisory Committee which advises NASA's Administrator.

Senator SCHMITT. Do they review and comment on the priorities?

Dr. KERREBROCK. Only in a general strategic sense. They do not review management decisions.

Mr. NYSMITH. Senator, we ought to point out that the number of proprietary tests requested by the industry is relatively small and those are the ones for which we are reimbursed.

Senator SCHMITT. Is that because the waiting line is so long?

Mr. NYSMITH. I think that is because they have some capability themselves at their plants to do the earlier development testing and they tend to come into the unique NASA facilities for the final development testing. The 12-foot tunnel at Ames and the unitary tunnel also at Ames are two such facilities they use a lot. But if they request time for that kind of testing they get in fairly quickly. They do not go to the tail of the line.

Senator SCHMITT. Do you have any means of estimating the proportion of facility time that is devoted to DOD projects versus that devoted to commercial projects?

Mr. NYSMITH. We have that data.

Senator SCHMITT. Would you provide that to the committee, please, and, of course, broken down with the in-house use as well? If you could just give us a breakdown of the proportion of use by NASA, by DOD, and by commercial and other interests.

Mr. NYSMITH. That is of the major facilities?

Senator SCHMITT. The major facilities, yes. Could you provide for our record a clear, short, concise distinction between technology validation and technology demonstration?

Dr. KERREBROCK. We will try, sir; however, the line is fuzzy. Let me say that as we currently interpret those two terms, validation means validation for incorporation in production aircraft. Demonstration is generally interpreted as a demonstration of the technical feasibility of some concept. If you would like a further clarification of that, we can try, but I believe that different people and reasonable people will differ as to where the boundary would be put.

[The following information was subsequently received for the record:]

The following chart reflects the use of major NASA aeronautical facilities over the past five years. The DOD and industry data differentiates between work performed solely for the requestor versus that which is cooperative with NASA.

Utilization of NASA major aeronautical facilities (1977–81)

	Percent
NASA in-house	50.8
NASA-DOD	24.4
DOD request	13.7
NASA-industry	7.0
Industry proprietary	2.9
Other U.S. Government	0.7
Foreign	0.5
Total utilization	100.0

In our use of the terms Technology Demonstration and Technology Validation, we try to be consistent with the definitions developed at the National Research Council's 1980 workshop on NASA's role in Aeronautics, as follows:

Technology Demonstration.—Programs conducted to demonstrate the technical feasibility of a technology advance or concept. Activities may include flight testing and component or systems demonstration.

Technology Validation.—Programs that include large-scale ground or flight validation as a necessary step to assure technology transfer. The purpose is to make possible, with minimal risk and without additional technology development, the practical utilization of high-risk conceptual, component or subsystem technology advances.

These definitions, of course, provide only a shorthand description of a program, and generally do not convey a full understanding of the nature and value of the program. The Tilt Rotor Research Aircraft and the Quiet Short-Haul Research Aircraft, for example, demonstrate the technical feasibility of the tilt rotor and the upper-surface-blown-propulsive-lift concepts. They are thus categorized as demonstration programs, but they also provide test vehicles used for years in valuable flight research much of which is independent of the concept itself. Similarly, while the Composite Primary Aircraft Structures program validates this technology for medium-sized composite structures on widebody transports, the program also accomplishes essential long-range research, providing an understanding and a data base for both industry design and government certification of composite structures on future civil and military aircraft.

Program designed specifically for either technology demonstration or technology validation are rare, particularly for the latter. Such programs would be undertaken only when essential to reduce the high risk associated with a technology advance of potentially great national benefit.

Senator SCHMITT. Let us say your research is developing a composite—let me try a different example. Let us say it is a new turbine blade which you have done a lot of work on and still do. You have presumably done testing, a variety of testing on the blade itself as an individual component.

Then you probably put it into a turbine and test it on how it interacts within the turbine itself. Now is that a validation study—the blade in the turbine?

Dr. KERREBROCK. Not necessarily. In that case, there are several questions that have to be answered. One has to do with the performance of the blade—the aerodynamic behavior. That would be a part of a demonstration usually. But to validate that turbine blade for incorporation into a production engine, you have to answer questions about lifetime and durability which are very difficult and expensive questions to answer because you have to run the blade for long periods of time.

Senator **Schmitt**. Now is that the kind of thing that you would expect the user community should do and not NASA?

Dr. **Kerrebrock**. Yes, sir. NASA does very little of that.

Senator **Schmitt**. Isn't demonstrating that the blade will work to meet certain test objectives really a part of the R. & T. effort that you would put in place for a blade?

Dr. **Kerrebrock**. That is right, to meet performance objectives.

Senator **Schmitt**. Have you assessed the aggregate estimated costs to private industry to carry through the technology demonstration phase if they were forced to do that? Frankly, I am with you. I do not see how you distinguish these things.

Dr. **Kerrebrock**. If it is technology demonstration, then I think we could estimate it because our programs, such as the aircraft energy efficiency program which we are drawing down, was designed to give a demonstration of an advanced engine technology. Now, validation of those engines for production is another issue and I would not be prepared to estimate the cost of that.

Senator **Schmitt**. Would you try to provide us with some estimates of those programs that are being phased out or terminated and what you expect the runout costs to be if the private sector took them over?

Dr. **Kerrebrock**. Yes, we could do that.

[The following information was subsequently received for the record:]

The following table is a summation of those major programs that are to be phased out by NASA, with estimates of the projected costs required by industry to carry them through technology demonstration. Costs associated with the necessary refinement and application to specific designs and/or product development are not included. Since proprietary aspects would preclude access to other company data, the projected costs would be those incurred by each company choosing to undertake the effort.

Technology—estimated cost through demonstration

	Millions
Energy efficient transport	$5
Composite primary aircraft structures	85
Advanced turboprop	190
Laminar flow control	75
Energy efficient engine	10

Senator **Schmitt**. Do you know if private industry has made any comparable estimates?

Dr. **Kerrebrock**. I do not.

Senator **Schmitt**. Would you expect private industry technology demonstration efforts to be more expensive or less expensive than NASA efforts?

Dr. **Kerrebrock**. I would expect it to be roughly the same because the only difference in the cost of carrying out these programs either through Federal funding or through Government funding is the Government overhead—the NASA overhead, which is very small.

Mr. **Nysmith**. Except that each company would have to do it on its own.

Dr. **Kerrebrock**. Yes. I was thinking of an individual effort.

Senator **Schmitt**. So if they work with NASA they can do it jointly. If they work outside you multiply the costs by the number of companies that have to do it individually and separately.

Dr. **Kerrebrock**. That is a very important point.

Senator **Schmitt**. I keep trying to get NASA to bring that out and I always have to ask the question.

Dr. **Kerrebrock**. May I expand on that very slightly?

Senator **Schmitt**. Yes, please do.

Dr. **Kerrebrock**. To go back to the energy efficient engine program again, because it is one of the more important programs, the General Electric Co. and Pratt and Whitney were both part of the program. The engine concepts that those two engine companies were working under the program are quite different and each of them incorporates high risk technology in different places.

Since the Government is funding those programs with the companies, the information on both concepts is available to the whole engine community. Therefore, when the time comes to develop a commercial or military engine each of the two companies has access to all of the technology instead of just the part that they do. So, the total is more than the sum of the parts for each company.

Senator **Schmitt**. Plus the antitrust umbrella.

Dr. **Kerrebrock**. Yes, sir.

Senator **Schmitt**. Senator Cannon.

Senator **Cannon**. Nothing further.

Senator **Schmitt**. What are the probabilities of foreign governments and their allied aircraft companies executing similar technology programs to what NASA has done in the last decade or so?

Dr. **Kerrebrock**. The European aircraft community is making a very aggressive effort to press their technologies forward. In many of the areas that are critical to commercial aircraft, certainly, Airbus Industries is fully competitive with U.S. manufacturers. The Japanese also are entering the engine development domain in cooperation with Rolls-Royce at the present time. They are making a very serious cooperative effort between the industries and the governments.

Senator **Schmitt**. Would you provide us for our record an assessment of the research and technology efforts comparable to NASA's that are under way in our major competitors? Do you watch that?

Dr. **Kerrebrock**. Yes, we do. The numbers are difficult to acquire, but we will give you what we have.

[The following information was subsequently received for the record:]

In conjunction with the Office of Science and Technology Policy's Study of Aeronautical R&T policy, we are developing a thorough assessment of foreign activity in support of their aeronautical industries. We will provide you with a summary of the data developed in this study when it is completed.

Our previous attempts to ascertain levels of NASA-comparable activities provided by foreign governments have been complicated by large amounts of development support contained in their budgets. The current assessment, in conjunction with the Department of Commerce, is providing a large amount of information from which we should be able to discern both the levels and comparability of their activity in aeronautical R&T.

The following table is a brief summary of the number of major wind tunnel facilities in four European countries with the comparable number of NASA facilities. It is included as an illustration of the general character of European research capability relative to U.S. capability. In the complete survey, the characteristics of these and other foreign facilities will be defined in more meaningful detail.

Type	NASA	Germany	France	United Kingdom	Netherlands
Low speed	8	5	6	4	1
Transonic	10	4	3	3	1
Supersonic	3	[1]3	3	2	1
Vertical/spin	1		1		

[1] Transconic and supersonic.

Senator **Schmitt**. Well, numbers can be approximated, but just what are the efforts; do they exist? Is there a Lewis Laboratory pronounced with a Japanese accent or something like that?

Dr. **Kerrebrock**. Not yet, but there is one with a German accent which modeled after our laboratory.

Senator **Schmitt**. If you could supply us with an inventory to the best degree you possibly can without entering into a major research program, I would appreciate it.

Lockheed has indicated that the problem with the wing of the C-5A was one of being held to a particular empty weight contract number. Whether that is true or not, had we had the numerical aerodynamic simulator at the time of the design of the C-5A, could we have anticipated the problem?

Dr. **Kerrebrock**. It is entirely possible that with a more sophisticated computational capability we could have predicted the fatigue life of the C-5A wing more accurately. Had we been able to do that in the design process it would have been possible to design the wing for the required life.

What happened with the wing was that it was designed to very, very stringent weight limits and the net result was that its fatigue life was shorter than we would have liked. Certainly a more sophisticated design capability helps in such a situation and the numerical aerodynamic simulator would give us that.

Senator **Schmitt**. Doctor, I wish that we could continue direct conversation on this. We will have to submit our questions for the record in order to move on.

I would not be surprised if once we get through with this budget cycle that we are going to want to just sit down and have a hearing specifically dedicated to more of these problems and discussions. I do not think we will resolve the issues fully as we go through this budget cycle and maybe by the next one we will have come to some kind of a consensus on how to handle the problems that have been created, I think, by the administration.

Thank you very much.

Dr. **Kerrebrock**. We will look forward to that.

[The statement follows:]

Statement

of

Dr. Jack L. Kerrebrock
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Science, Technology and Space
Committee on Commerce, Science and Transportation
United States Senate

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to represent the Office of Aeronautics and Space Technology (OAST) and present to you NASA's proposed FY 1983 Aeronautical Research and Technology program and budget. I will be presenting only highlights of the program and accomplishments over the past year, as time is insufficient to cover the full range of activities.

The FY 1983 Research and Development (R&D) budget for Aeronautical Research and Technology is displayed in Figure 1, along with the R&D budget history for the two previous years. Within the Administration's guidelines for Federal spending and its philosophy for R&D support, we have developed the FY 1983 budget request of $232 million, as well as the distribution of these funds between the Research and Technology (R&T) Base and Systems Technology elements, as shown on the figure. The R&T Base budget of $182 million, which is $18 million greater than our current figure for FY 1982, continues to support a program whose principal objective is to advance critical technologies and basic understanding in the major aeronautical disciplines of aerodynamics, propulsion, materials and structures, guidance and controls, and human factors. The budget for Systems Technology efforts has been reduced to $50 million as a result of termination of programs focused primarily on commercial aviation needs in which it appears appropriate for the private sector to play a larger role. However, Systems Technology efforts for rotorcraft and high-speed aircraft have been retained because of their importance to future military systems.

The FY 1983 budget request, as shown in Figure 2, is divided into three major categories. The disciplinary research and technology, which accounts for 62 percent of the total budget, primarily consists of long-term activities which are relatively basic and broadly applicable to all vehicle classes. This is high-risk, relatively fundamental work, critical to the generation of a technology base for future aircraft -- civil or military. It capitalizes on the unique blend of in-house NASA facilities and expertise, the university research community and the research capability in industry. The vehicle class technology effort for FY 1983 is divided about evenly between the low-speed and high-speed aircraft classes. Primary emphasis is being placed on advanced rotorcraft concepts and on high-speed military aircraft.

The allocation of the FY 1983 Aeronautical R&D budget request by center and the major roles of the Research Centers are depicted in Figure 3. The bulk of the budget is distributed to the Ames, Langley, and Lewis Research Centers. Each is a center of excellence in one or more technical areas, having expert scientists and engineers as well as unique facilities. This capability has taken decades to develop and is a major national resource. We place a high priority on its preservation, development, and efficient utilization for both the civil and military sectors of the United States aviation industry. Maintaining the Research Centers in positions of undisputed excellence requires the introduction of new facility capabilities, improving the productivity and capacity of operating R&D facilities, and improving computational capabilities as well as continually sharpening and modernizing the technical skills of the civil service workforce.

The Langley Research Center is the center of excellence in airframe technology for commercial and military transports, general aviation aircraft and military tactical aircraft. Included are both unique facilities and highly advanced computational capabilities in the areas of aerodynamics, fundamental fluid dynamics, unsteady aerodynamics and aeroelastic behavior, vehicle structural analysis and advanced materials, computer aided design technologies, flight mechanics and controls, and operational systems evaluation through simulation and flight facilities. Unique facilities at Langley include the 8-foot and 16-foot transonic wind tunnels, the Transonic Dynamics Tunnel, the 8-foot High Temperature Structures Tunnel, the Aircraft Landing Dynamics Facility, and the Aircraft Noise Reduction Facility. During FY 1983, the National Transonic Facility will be operational to provide the Nation with the world's most advanced high Reynold's number facility. The Avionics Integrated Research Laboratory will also become operational to perform research in advanced aircraft controls and investigate highly reliable fault-tolerant control

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systems. Construction of Facility (CofF) funds are being requested in FY 1983 to increase the density range of the Transonic Dynamics Tunnel by 50 percent to enable scaling of key aeroelastic parameters for current and anticipated future aircraft designs. The 4x7 meter Low Speed Tunnel will also be modified to increase its operational efficiency and productivity.

Our Ames Research Center, including the Dryden Flight Research Facility, is the center of excellence in flight research and in those disciplines essential to commercial and military rotorcraft, short-haul and V/STOL aircraft. The Ames capabilities and accomplishments include the 40x80-foot wind tunnel which is now being upgraded to higher speed and a larger test section with an 80x120-foot addition. This new capability will come on line in FY 1983 and will allow testing of full-scale vertical and short-takeoff and landing aircraft. At Ames, we can test a single model from subsonic through supersonic speeds in the unitary plan wind tunnels. Other unique facilities include the high temperature arc-jet laboratory, advanced flight simulators, and advanced computational facilities. The new Man-Vehicle Systems Research Facility will become operational in FY 1983. It will provide full mission, ground test simulation of multiple aircraft, terminal area air traffic control and aircrew interactions, and advanced technology cockpit displays representative of future generations of aircraft. It will uniquely satisfy a national requirement for aeronautical human factors research. The Dryden Facility represents the preeminent flight testing capability in this country and is the primary site for initial Shuttle landings. CofF funds are being requested in FY 1983 to construct a new central data analysis facility.

The Lewis Research Center is our aeronautical propulsion research and technology center and has major engine and engine component test facilities, and expertise in and facilities for internal computational fluid mechanics, and studies of high temperature materials, rotating machinery, and power transmission. Unique facilities include the Engine Research Facility, Propulsion System Laboratory, high temperature turbine and compressor facilities, propulsion wind tunnels, icing research facilities, and space propulsion test facilities. CofF funds are being requested in FY 1983 to modify the Engine Research Facility by addition of a new air compressor to replace and supplement the present aging machine.

As a result of the reorganization which was implemented last December at NASA Headquarters, the Ames, Langley and Lewis Research Centers now report to this office. As shown in Figure 4, the new organization establishes a clear distinction between line and staff functions at Headquarters and should improve the management of the centers by having them report directly to the designated

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Associate Administrators who are responsible for most of the program activity at the centers. In coordination with the Research Center Directors, I will formulate and have overall management responsibility for their CofF and Research and Program Management (R&PM) budgets. I believe this reorganization will provide strong, centralized management direction for both programs and institutions.

The added institutional responsibility at the three NASA Research Centers is compared to my continuing responsibility for management of the Aeronautics and Space Technology R&D programs in Figure 5. As shown on the right, more than 60 percent of the OAST institutional and R&D budgets are being applied to aeronautics R&T. In addition to these direct appropriations to NASA, there is also approximately $20 million of reimbursable R&D funding primarily from the Department of Defense (DOD) which supports our aeronautics program.

The unique national aeronautical facilities and expertise developed by NACA and NASA over the last half century are widely utilized to perform research in cooperation with other Federal agencies. For example, NASA works very closely with the FAA to provide the fundamental technology to improve the efficiency and safety of the National Air Transportation System as well as the safety of general aviation aircraft, rotorcraft and transport aircraft. A substantial portion of the low-speed aircraft technology program is conducted in close cooperation with the Army. Also, several elements of the program are conducted in cooperation with the Navy and the Defense Advanced Research Projects Agency (DARPA). The military activity is directed toward long-term research on rotor systems and advanced rotorcraft propulsion systems. NASA also works very closely with DARPA, the Air Force and the Navy in research and technology efforts related to high-speed aircraft. Evolving new concepts in aerodynamics, flight dynamics and controls, aeroelasticity, propulsion and propulsion/airframe integration are investigated for application to strategic and tactical aircraft, vertical takeoff and landing aircraft, and missiles.

I would like to describe the proposed activities for FY 1983 and briefly discuss in more detail some of the accomplishments and plans of our major areas of emphasis. Categories are Disciplinary Research and Technology, Low-Speed Technology (rotorcraft), and High-Speed Aircraft Technology. Also included is a discussion of the status of the Aircraft Energy Efficiency Program.

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Disciplinary Research and Technology

Aerodynamics - The major focus of the aerodynamics program is to develop the analytical tools, aerodynamic facilities, and base of knowledge needed to improve the aerodynamic performance of aircraft and missile systems. Research directions for FY 1983 include new developments in numerical analysis and the application of more powerful computers; the application of advanced technology wind tunnels; reduction of turbulent friction drag on fuselages and wings; investigations of natural laminar flow airfoil designs; fundamental supersonic and hypersonic research; and stall spin research for general aviation aircraft.

A major thrust has been in the field of computational fluid dynamics. The development of new techniques will reduce computational time, and thereby, the cost of solving complex fluid flow problems. Recent improvements at Ames and Langley in numerical algorithms for two-dimensional viscous flows promise reductions in computing time by more than a factor of twenty. This may allow the completion of complex flow solutions in minutes rather than the hours it took before. Emphasis in FY 1983 will be on extending numerical algorithms, geometric modeling and grid generation techniques to three-dimensional viscous flows. An important element of this continuing effort is the Numerical Aerodynamic Simulator for which two preliminary design studies were recently completed. Proposals are in preparation and a detailed evaluation of the proposals will commence in the near future.

This past year, experimental studies using large eddy breakup devices have yielded new results in turbulent drag reduction. Low-speed wind tunnel tests at Langley have indicated that it may be possible to reduce turbulent skin friction by as much as 20 percent using these surface attached devices. Since friction accounts for approximately one-half of the total drag of aircraft at cruise conditions, reductions of this magnitude would mean tremendous fuel savings. The eddy breakup devices would be applicable to fuselages where very high Reynolds number flow makes laminar flow control impractical. Testing of the devices will be performed in FY 1983 at higher Reynolds numbers on flat plates and airfoils.

In the area of general aviation research, improved methods for the design of natural laminar flow airfoils have been experimentally validated in the Langley Low Turbulence Pressure Tunnel. These airfoils reduce drag by delaying turbulent transition while achieving high lift for takeoff and landing. Drag coefficient reductions of up to 40 percent have been achieved experimentally. Wind tunnel and full-scale flight tests indicate that drag reductions of more than 10 percent are feasible during cruise. During FY 1983, flight tests with a

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partial span wing glove having a modern natural laminar flow airfoil will be conducted. The tests will study methods for overcoming adverse environmental effects, such as ice formation and insect contamination, and will examine three-dimensional wing design requirements and limitations.

Propulsion - This program is directed at providing the fundamental understanding and generic technology that will allow for continued improvements in aircraft propulsion performance, efficiency, reliability and durability, as well as reduce engine fuel consumption, environmental impact and operating costs. The program encompasses research in the areas of turbomachinery components and internal computational fluid dynamics; combustion and fuels; inlets and exhaust nozzles; engine system dynamics and controls; advanced bearings, gears and seals; noise reduction; and supersonic combustion ramjets. These activities provide the technology advances that will lead to propulsion system improvements for a broad range of vehicle applications ranging from small, general aviation aircraft to commercial transports and helicopters to military aircraft of all types.

An increasingly significant portion of our propulsion program continues to be focused on advances in internal computational fluid dynamics for turbomachinery. Efforts at Lewis are focused on developing analytical methods to predict the steady and unsteady flow and thermal response associated with the complex flow through rotating blade passages in fans, compressors, propellers and turbines. Development of a comprehensive computer code capable of modeling three-dimensional inviscid flows in compressor blade rows has been completed at Lewis. This effort will ultimately lead to the design of tailored airfoils which control shock location, shock strength, and secondary flows for improved pressure ratio, efficiency, and operating range. In FY 1983, emphasis will be on the capability for analysis of complex, three-dimensional viscous internal flows. Efforts will continue to develop faster computational methods, and to develop algorithms tailored to exploit the capability of high-speed computers. Detailed flow and heat transfer investigations will continue with emphasis on boundary layer behavior, secondary flows, turbulence structure, and rotational effects.

Fuels research underway at Lewis is developing a fundamental data base relating the chemical and physical properties to performance of current and potential future aviation fuels. Emphasis is on establishing a detailed understanding of the relationship of chemical composition and molecular structure to characteristics such as thermal stability, viscosity and freeze point, and ultimately to engine effects in terms of combustion, emissions, component performance, and durability. Research activities in FY 1981 focused on the study of

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thermal stability. This is a measure of a fuel's tendency to decompose during long-term storage or when exposed to high temperature surfaces. It was found that the rate of deposit formation was a function of total nitrogen content and was strongly dependent upon the specific chemical structure and the type of nitrogen compounds present. In FY 1983, research will emphasize advanced fuel analysis techniques, improved understanding and control of specific instability reaction mechanisms and rates, and the behavior of fuels at or near their freezing point.

Nonrecoverable stall has become a significant factor in engine performance, causing aborted missions and the loss of aircraft, particularly with high-performance military aircraft engines. A nonrecoverable stall occurs when a compressor surge or stall causes an engine to depart from its normal operating mode and settle at an inefficient condition that requires shutting down and restarting the engine in flight. A comprehensive program to better understand engine stall is underway as part of a cooperative program with the Air Force. NASA is exploring causes of engine stall and recovery for high-bypass-ratio engine systems. Currently, system dynamic modeling is underway in conjunction with systems interaction testing of a high-bypass-ratio engine. In FY 1983, the system dynamic analysis will be extended to include both stall avoidance and stall recovery models, compressor design criteria, and benchmark performance data.

NASA is placing increased emphasis on understanding the noise generating process for rotorcraft and advanced turboprop-driven aircraft. In 1983, the aeroacoustic data base for propellers and helicopter rotors will be expanded through tests in the 8x6-foot wind tunnel at Lewis and in the V/STOL wind tunnel at Langley. Analytical research will focus on improved modeling of the unsteady aerodynamics using advanced computational methods and on the development of validated near- and far-field noise prediction methods which take into account non-linear terms and transonic compressibility effects.

Also, propulsion research for general aviation aircraft is providing the technology base for advanced intermittent internal combustion engines with jet fuel and multifuel capability, reduced fuel consumption, reduced weight, and emissions. The two most promising advanced engine concepts are a high speed, liquid-cooled rotary engine and a stratified charge piston engine. We are currently modeling the combustor to provide an understanding of processes that control engine efficiency, emissions, and fuel requirements. Research on rotary apex seal materials, fuel injection and stratified charge combustion, engine cooling, and high efficiency turbocharger technologies will be addressed in FY 1983. Engine and component testing is conducted in facilities at both Lewis and in the industry. Universities, supported by NASA grants, are involved in combustion modeling and research on advanced component technologies.

Materials and Structures - During FY 1983, materials and structures research will maintain its strong emphasis on advanced structural and materials concepts; composite materials application, life prediction, thermal and dynamic response, and aeroelasticity; development of efficient computational methods for structural analysis and design; and improved experimental techniques for future airframe and engine systems. Recent research to increase performance, energy efficiency, and flight safety continues to provide high payoff to both military and commercial aircraft systems.

Our materials and structures research has a major effort in computational analysis. In recent years, optimizing the design of high-performance military and commercial transports has become increasingly more difficult. As vehicles become more complex and mission requirements more demanding, the requirement for more detailed structural analysis has led to significant escalation in the cost and time for performing structural calculations. Langley has developed a proof-of-concept computer utilizing microprocessors capable of performing structural analysis at computational speeds ten times faster than current finite element methods. In FY 1981, we successfully demonstrated a 16-processor configuration which was utilized to investigate solution algorithms for several small structural problems. In FY 1983, computer hardware options, including the type and organization of 36 individual processors, will be investigated and numerical solution algorithms will be further developed.

Advanced composites research is receiving heavy emphasis in our materials and structures program. Today's advanced fighter aircraft have large components built from composites to reduce weight compared to metal construction. Lighter weight contributes to the greater speed and maneuverability required in combat. The most widely used current composite materials are composed of an epoxy matrix reinforced with graphite fibers. Unfortunately, current epoxy matrices lack toughness, are sensitive to moisture, and have variable properties. Present design practices allow for these limitations, but the allowance tends to reduce the weight-saving potential for heavily loaded applications in large military and civil aircraft. We have embarked on an extensive effort to improve matrix resin materials. The principal objectives of the work are to provide tougher, more readily processible composites that are environmentally durable. Recent experimental advanced resins have been found that could lead to much tougher composites able to withstand greater strain and impact loading associated with large structures, such as large transport wings. During FY 1983, research will concentrate on the durability and damage tolerance of these tough polymer resins.

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Complementary to the high-performance, lightweight airframe research effort is a major thrust in gas turbine engine materials. A portion of our program has been focused on research to conserve the Nation's strategic materials. The United States is not self-sufficient in certain strategic metals required for alloys used in gas turbine engine components. It is necessary to import virtually all cobalt, columbium, tantalum, and chromium needed for today's superalloys. In FY 1981, Congress recognized the significance of the problem and increased NASA funding to begin research on methods to reduce the vulnerability of the country to supply instabilities of these materials. Research at Lewis on cobalt's effect on microstructure and design properties could provide the opportunity to reduce cobalt content without sacrificing properties. During FY 1983, new classes of materials containing no strategic elements at all will be investigated. Nickel aluminide intermetallics, although currently too brittle for engine applications, are one such material. Research will be directed at methods to increase the ductility of this potentially superior material.

Controls and Guidance - The objectives of the controls and guidance program are to provide the fundamental knowledge base of information and control theory for analyzing the performance of aircraft; to develop mathematical control laws and design methods for extending the performance envelope and reliability of future civil and military aircraft; to devise analytical methods and techniques for assessing the performance of large-scale, complex integrated systems; and, to investigate emerging technologies which offer future alternative approaches for continued aviation safety and efficiency. Major thrusts are applied control theory, flight path management, flight-crucial systems which include fault-tolerant architectural concepts, system assessment methods, and environmental effects research.

The flight path guidance activities provide advanced technology to improve the efficiency and safety of flight in the evolving National Airspace System, including optimal guidance algorithms, traffic flow management concepts, operational procedures and crew interface concepts. An important and practical guidance algorithm, developed at Ames, allows aircraft to fly optimal flight paths from takeoff to landing that will minimize fuel and time-of-flight taking into account air traffic control restrictions and weather. Much of industry is now using optimal flight path concepts. In FY 1983, the algorithm will be further developed to meet specific time of arrival constraints and it will also be expanded to conduct traffic flow management research with the FAA to increase traffic flow capacity. A major FY 1983 emphasis will be in the technology base for a highly automated crew flight station. A simulator to explore advanced concepts will be developed at Langley.

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Research in meteorological hazards to aviation will continue at Langley using two flight research aircraft to characterize severe storms and the effects of lightning and turbulence on future aircraft and operations. The data will be used by NASA and DOD in FY 1983 to develop mathematical models of lightning-induced errors in digital systems and as input test signals in laboratory experiments to characterize the effect on aircraft components such as fault-tolerant computers and nonmetallic aircraft structures. The FAA is also participating in this research and will use the data in future aircraft qualification. Icing research at Lewis will include development and evaluation of improved icing sensors, scaling laws and the study of modern airfoils under icing conditions. Improvements in wind tunnel productivity for icing experiments are planned using improved aerodynamic measurement devices. Interagency agreements on icing research have been developed between NASA, the Air Force and the FAA.

Human Factors - An improved understanding of aircrew capabilities and the limitations they place on the growth, safety, and efficiency of air transportation is the goal of our human factors research. The program encompasses flight management, simulation technology, workload and performance measurement. Studies of human response to noise are also included.

In the area of flight management, a number of significant experiments have been completed under the joint NASA/FAA Cockpit Display of Traffic Information (CDTI) program. These evaluate a pilot's ability to use CDTI to perform maneuvers such as spacing and merging, which could otherwise be done only by an air traffic controller. The CDTI research in FY 1983 will focus on the interaction of CDTI and a collision avoidance system.

Any aviation research involving interaction with the air traffic control system must have the capability to simulate interactive traffic in order to achieve an acceptable level of experimental validity. Presently, such traffic can be generated only through the use of pilots with a simple control device. To increase experimental flexibility and reduce research costs, NASA has been developing computer models of the pilot/aircraft system which could be used to generate interactive traffic. In the past year, a model of a pilot flying a CDTI-equipped aircraft in an airport traffic area was developed and validated. While it will be very useful in CDTI research, the model is limited in output to the aircraft flight profile. The FY 1983 focus of this research is on development of a model of the entire flight crew, which incorporates all of their information sources, cognitive processing, and behavioral outputs such as monitoring, discrete and continuous contact, and communications.

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NASA research on aviation safety includes the Aviation Safety Reporting System (ASRS), which NASA manages for the FAA. Its purpose is to identify deficiencies and discrepancies in the national aviation system and to provide a comprehensive data base for human factors research. The ASRS data base, presently numbering over 30,000 reports, was heavily used by the Presidential Commission on Crew Complement and by the FAA, the National Transportation Safety Board, the Flight Safety Foundation, and Congress during investigations of the air traffic controllers strike. Also, frequent requests for use of NASA's aeronautical human factors expertise and facilities are made by civilian and military organizations. NASA provided significant support to the Air Force, Army and Navy, NATO-AGARD, the National Academy of Sciences, the DOD and the National Institute of Health.

Low-Speed Aircraft Technology

The Low-Speed Aircraft Technology program is devoted primarily to R&T Base and Systems Technology efforts related to rotorcraft. The majority of the rotorcraft technology activity is conducted in close cooperation with the Army Aviation Research and Development Command through three Army Research and Technology Laboratories co-located at Ames, Langley and Lewis. Some segments of the Low-Speed Aircraft program are also conducted in cooperation with the Navy and DARPA in support of military technology needs. Similar coordination takes place between NASA and the FAA in selected areas of rotorcraft research related to civil missions.

The objectives of the Low-Speed Aircraft R&T Base program are to provide a technology base in rotorcraft structures and dynamics, aerodynamics, acoustics, flight dynamics and control, man-system integration, and wind tunnel and flight experiments support. The objective of the Systems Technology program is to provide ground-based and flight research on integrated systems which hold long-term promise as viable military and civil rotorcraft concepts. The program covers the broad technology areas of configuration aerodynamics; propulsion; integrated flight systems including controls and guidance; and structural systems including advanced materials applications, vibration reduction, noise reduction and performance improvement. The experimental ground-based and flight testing is closely coupled with the co-located Army Laboratories and complements the NASA and Army R&T Base activities.

Noise is a top priority with the helicopter industry and with local communities. NASA is focusing increased attention in the area of helicopter noise with the goal of developing the technology necessary for the accurate prediction of the noise characteristics of new helicopter designs. The feasibility of reducing noise while maintaining rotor performance is being investigated in a

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series of helicopter model tests in the Langley 4x7-meter wind tunnel. In addition, an initial flight test effort was completed utilizing the YO-3A aircraft to obtain in-flight noise data on a highly instrumented AH-1G helicopter. This aeroacoustics flight research provided simultaneous data on radiated noise and rotor airloads, which will now form the basis for developing analytical prediction methods.

An important element of long-term research on rotor systems is the availability of the unique research capability embodied in the two Rotor Systems Research Aircraft (RSRA) now in operational status. A helicopter configuration is now in flight research status following detailed calibration of onboard instrumentation and load-measurement systems. Experimental programs on rotor/fuselage aerodynamics and stability and control are now underway. The second aircraft, in the compound configuration which results from adding a wing and auxiliary engines to the helicopter, is also in flight status. Calibration of this aircraft and initiation of an extensive flight-test program are planned to establish a detailed comprehensive data base utilizing the S-61 rotor system.

A joint NASA/Army Tilt Rotor Research Aircraft activity involves two research aircraft, which are currently undergoing a series of flight tests to verify tilt rotor technology through proof-of-concept testing, detailed flight envelope documentation, and mission suitability testing. The joint effort was initiated in the early 1970's, and the two aircraft are now operational. One aircraft participated in the 1981 Paris Air Show and demonstrated, with considerable success, the unique capabilities inherent in the tilt rotor concept. The initial flight research investigations have been completed in the areas of performance, downwash, noise and handling qualities. The flight envelope is being carefully documented, and speeds up to 300 knots have been achieved at altitudes to 21,000 feet. One aircraft has been returned to Bell Helicopter Textron for systems upgrading and a series of flight demonstration activities. Future activities will include continuation of flight envelope documentation at alternate weight conditions and extended flight demonstrations in support of the Army, Navy, Marines and Air Force.

High-Speed Aircraft Technology

The High-Speed Aircraft Technology program consists of both R&T Base and Systems Technology activities, many being cooperative programs with industry, DARPA, Air Force, and Navy. Efforts address advances in aerodynamics, flight dynamics and controls, propulsion and airframe/propulsion integration for a variety of high-speed military vehicles, including advanced tactical aircraft, powered-lift vertical takeoff and landing

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airplanes, air-breathing and rocket propelled missiles, and hypersonic vehicles.

In FY 1983, analytical studies and wind tunnel model construction and testing will be aimed at concepts for the next generation of advanced tactical aircraft. Evolving technologies such as active canard controls, non-axisymmetric nozzles, and flight/propulsion control integration will be explored. Since most concepts for future high-performance tactical military aircraft incorporate non-axisymmetric (two-dimensional) nozzles which offer benefits in thrust vectoring, thrust reversing, reduced infrared signature and reduced number of moving parts, NASA will continue its research on these advanced nozzles. FY 1983 activities will include design studies, small-scale nozzle tests, and full-scale tests of a Navy-developed Augmented Deflector Exhaust Nozzle mated with the F-404 engine under a cooperative NASA/Navy effort. In addition, an advanced two-dimensional nozzle with high-temperature carbon/carbon materials will be tested.

Efforts will continue in response to military interest in subsonic and supersonic V/STOL aircraft. The major activities on subsonic V/STOL are in aerodynamics, flight simulation, and propulsion components. Initial full-scale model subsonic tilt nacelle aircraft tests and simulations were recently completed. Modifications found necessary to improve controllability are currently being made in preparation for additional wind tunnel testing and simulation in FY 1983. Twin-engine supersonic V/STOL fighter model testing, without propulsion simulators, was also completed last year. Powered model testing will occur in FY 1983, and subsequent critical component validation is planned. Plans are also being made for tests of promising single-engine concepts developed in NASA/Navy studies.

The Turbine Engine Hot Section Technology (HOST) program includes the development of methods and instrumentation for analytical and experimental research on internal engine high-temperature environment and appropriate technology. Both the experimental and analytical methods will be verified in full-scale component tests. Final results will then be used to analytically define and optimize life of hot section components.

During the 1970's a coordinated NASA/Navy/Air Force effort was undertaken to generate basic parametric data for cylindrical-body/cruciform-fin supersonic missile configurations. Results of this research have been used in the assessment and design of a major new DOD missile. Other work is underway on the high speed aerodynamics of advanced concepts for long-range air-to-air missiles, surface-to-air missiles and air-to-surface missiles. Advanced hypersonic Mach 5 aircraft concepts are also being investigated. NASA is concentrating on techniques for integration of large inlets and nozzles dictated by the low air densities associated with very high altitudes. Advanced analytical techniques and computational procedures are being developed and validated to handle the design and analysis of unique and innovative future hypersonic configurations.

Major flight research activities are performed jointly with DOD organizations or directly in response to military agency requests. The free-world's first operation of an engine-mounted, full-authority digital electronic engine controller (DEEC) was achieved in a high-performance military aircraft in June 1981. In the Highly Maneuverable Aircraft Technology (HiMAT) program, a major portion of the design operating envelope has been cleared and considerable research data have been obtained. NASA is also working with the Air Force on the Advanced Fighter Technology Integration effort, under which an F-16 will incorporate an advanced digital fly-by-wire control system and canard surfaces for direct force control and an F-111 will incorporate a Mission Adaptive Wing to demonstrate the aerodynamic performance improvement of a smooth, variable-camber airfoil. First flights of these aircraft are scheduled for the spring of 1982 and FY 1983 respectively.

NASA's support to the DARPA-funded X-29A Forward Swept Wing Flight Demonstrator program will increase in FY 1983 to help ensure successful initial flights, which are scheduled to occur in early FY 1984. Previous and current activities include aeroelasticity tests in the Langley Transonic Dynamics Tunnel, low- and high-speed aerodynamic and inlet wind tunnel tests at Ames and Langley, and flying qualities simulation studies.

Aircraft Energy Efficiency Program Status

The Aircraft Energy Efficiency (ACEE) program, which began in 1976 at the request of Congress, was structured to accelerate both the development and application of fuel saving technology in view of the large projected worldwide markets for civil transports and the need for improved military cargo and tanker aircraft. The stated goal of the program was to provide new technology that, if implemented, could reduce fuel consumption by 50 percent relative to first-generation widebody aircraft and engines.

The six elements comprising the ACEE program are the Engine Component Improvement (ECI), Energy Efficient Engine (EEE), Advanced Turboprop (ATP), Energy Efficient Transport (EET), Composite Primary Aircraft Structures (CPAS), and Laminar Flow Control (LFC) programs. Of the six programs, ECI completed testing in FY 1981 having reached its goal of approximately 5-percent reduction in specific fuel consumption through improved components and maintenance procedures for current production engines.

Significant progress has been made in each of the remaining ACEE program elements, and the following sections provide the current status of each.

The Energy Efficient Engine (EEE) program is developing advanced component and systems technologies for a new generation of fuel efficient turbofan engines. In FY 1981, each of the major components was tested with excellent results as part of the component technology development effort, which is nearing completion. For example, rig tests of the General Electric fan resulted in efficiency levels that exceeded fully developed component goals, and the Pratt & Whitney high-pressure compressor was also successfully tested. The effort to determine overall system performance has been descoped. Currently, the high-spool components at General Electric are being assembled with other required subsystems as a core engine for testing, and integrated core/low-spool tests are planned for early FY 1983. Further emphasis will be placed on advanced component technology in the Pratt & Whitney program during FY 1982 and FY 1983. During FY 1983, plans will be formulated to determine the benefits to be derived from utilization of the EEE hardware as advanced technology testbeds. These testbeds could provide a valuable focal point for future in-house propulsion system research and for potential cooperative research efforts with industry.

The Advanced Turboprop (ATP) program has provided initial confirmation of early predictions of propeller (prop-fan) efficiency, installation drag, and noise reduction weight penalty which correspond to 15- to 20-percent fuel savings. The ATP program was structured to explore each of these areas and significant efforts have been initiated. Propeller research has provided a comprehensive data base of aerodynamic, acoustic, and aeroelastic characteristics for several blade shapes. In FY 1982, we plan to initiate the design, fabrication and test of an aeroelastically scaled prop-fan model as a step toward understanding large-scale structural dynamics of the propeller concept. Initial noise research indicates that a satisfactory passenger cabin environment can be attained without serious weight penalty, but large-scale ground experiments must be deferred in the descoped program. Wind tunnel investigations of model turboprop installations indicate that acceptable levels of drag due to nacelle and slipstream can be achieved through further optimization.

The Energy Efficient Transport (EET) program has provided a national research focus on subsonic transport advanced aerodynamics and active controls. At Lockheed, an active controls system known as maneuver load alleviation permitted the wing span of the L-1011 to be extended without structural modification. At Douglas, winglets have been flight tested on a DC-10-10 transport. Drag improvements of 6 percent at low speed and 2.5 percent at high-speed cruise were achieved, although buffet problems and discrepancies with wind tunnel results point to an inadequacy in predictive capabilities. At Boeing, the major EET activity has been in Integrated Application of Active Controls (IAAC). In-depth analysis indicates that active controls hold the potential for 10-percent greater fuel efficiency than current technology for transport configurations. In NASA Laboratories, a large data base has been established on wing designs incorporating aspect ratios up to 12, supercritical airfoils, reduced sweep, and winglets. The remaining EET activities include the Lockheed flight evaluations and the assembly and laboratory testing of the Boeing IAAC system.

The Composite Primary Aircraft Structures (CPAS) program completed the secondary structures programs with over 20 new components in flight service, and will complete the structural ground test, FAA certification, and flight checkout of medium-primary composite components. These achievements provided a major impetus to the introduction of lightly loaded composite structures on a number of emerging aircraft, and are providing a technical base for advancing to heavily loaded wing and fuselage primary structures, where the full potential benefits of 10- to 15-percent fuel savings and lower maintenance can be realized. All composite secondary structure elements were completed and FAA certified, and have accumulated thousands of flight hours in airline service. Progress in medium-primary stabilizer efforts has defined some of the technology challenges inherent in composite structures development, lifetime assurance, and certification. Using FY 1982 CPAS funds, the DC-10 and B-737 stabilizers will obtain flight service data, and the L-1011 stabilizer sub-components will complete 20 years of simulated environmental testing. However, medium-primary composite structure components have experienced sufficient development difficulty to indicate that the design technology for large, strength-critical composites is not yet in hand. Key technology study efforts for large primary structures are independently evaluating thick joints, fuel containment, and durability and damage tolerance for composite wing structures.

The goal of Laminar Flow Control (LFC) systems technology is a practical, reliable, maintainable LFC system concept for future transport aircraft. The initial program phase indicated that an economical LFC transport with fuel savings of up to 20 percent could be developed if critical issues concerning practicality could be satisfactorily resolved. Accordingly, a second phase was begun featuring wing leading-edge flight tests, wing surface systems development and wind tunnel experiments. Fabrication was initiated on representative LFC leading-edge wing boxes for installation on a NASA JetStar for flight tests in different geographical locations and meteorological conditions. Wing surface sections were designed to investigate both structural concepts and wing surface integration.

CONCLUSION

While there are some technology challenges that will have to go unmet because of budgetary constraints, we feel the FY 1983 budget request represents a balanced aeronautics program. We will endeavor to maintain the capability to respond to system technology needs in the future, and we will continue to advance the technology base in all key aeronautical disciplines. Our planned program will help maintain the United States at the forefront of aeronautics, for both military and civil applications.

AERONAUTICS RESEARCH & TECHNOLOGY

R&D BUDGET

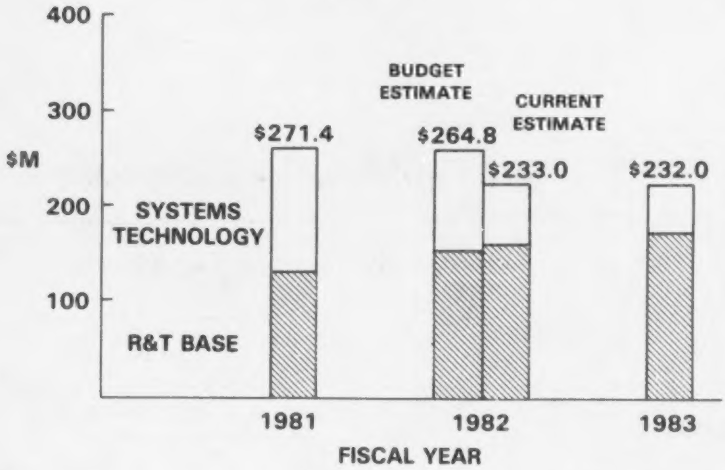

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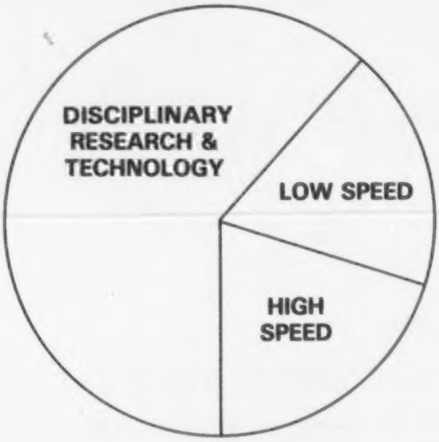
Figure 1

AERONAUTICS RESEARCH & TECHNOLOGY



FY 1983 R&D BUDGET
($232.0 M)

NASA

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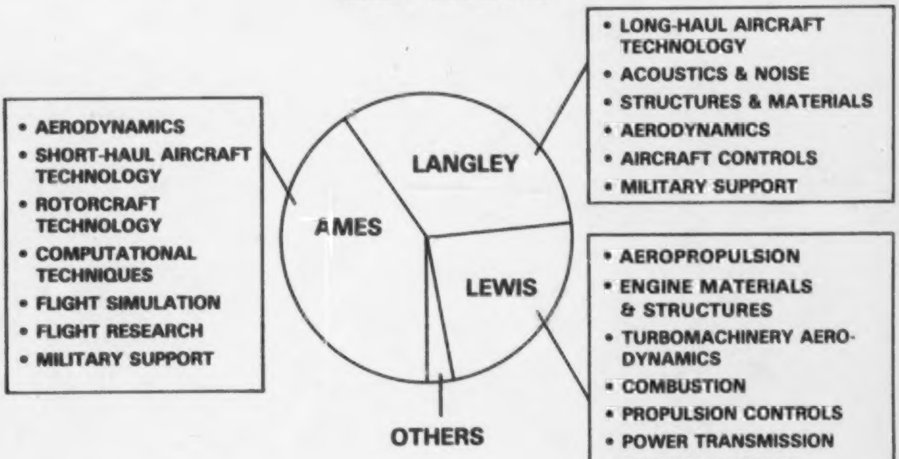
REV. 2 2 82

Figure 2

AERONAUTICS RESEARCH & TECHNOLOGY

CENTER FUNDING DISTRIBUTION AND ROLES
(R&D – $232.0 M)



- AERODYNAMICS
- SHORT-HAUL AIRCRAFT TECHNOLOGY
- ROTORCRAFT TECHNOLOGY
- COMPUTATIONAL TECHNIQUES
- FLIGHT SIMULATION
- FLIGHT RESEARCH
- MILITARY SUPPORT

- LONG-HAUL AIRCRAFT TECHNOLOGY
- ACOUSTICS & NOISE
- STRUCTURES & MATERIALS
- AERODYNAMICS
- AIRCRAFT CONTROLS
- MILITARY SUPPORT

- AEROPROPULSION
- ENGINE MATERIALS & STRUCTURES
- TURBOMACHINERY AERO-DYNAMICS
- COMBUSTION
- PROPULSION CONTROLS
- POWER TRANSMISSION
- MILITARY SUPPORT

NASA

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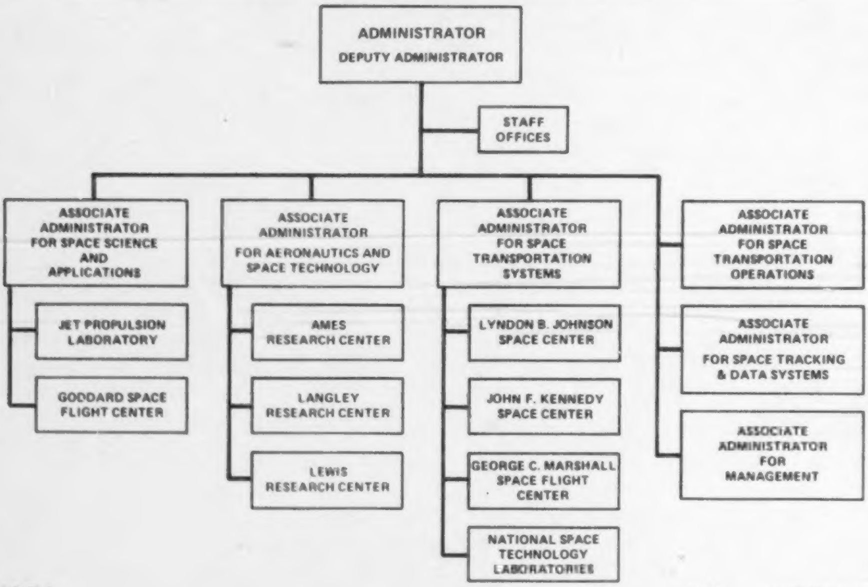
Figure 3

NASA ORGANIZATION



ADMINISTRATOR
DEPUTY ADMINISTRATOR

STAFF OFFICES

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- JET PROPULSION LABORATORY
- GODDARD SPACE FLIGHT CENTER

ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
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- LANGLEY RESEARCH CENTER
- LEWIS RESEARCH CENTER

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- LYNDON B. JOHNSON SPACE CENTER
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ASSOCIATE ADMINISTRATOR FOR SPACE TRANSPORTATION OPERATIONS

ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING & DATA SYSTEMS

ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

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Figure 4

OAST INSTITUTIONAL AND PROGRAM RESOURCES

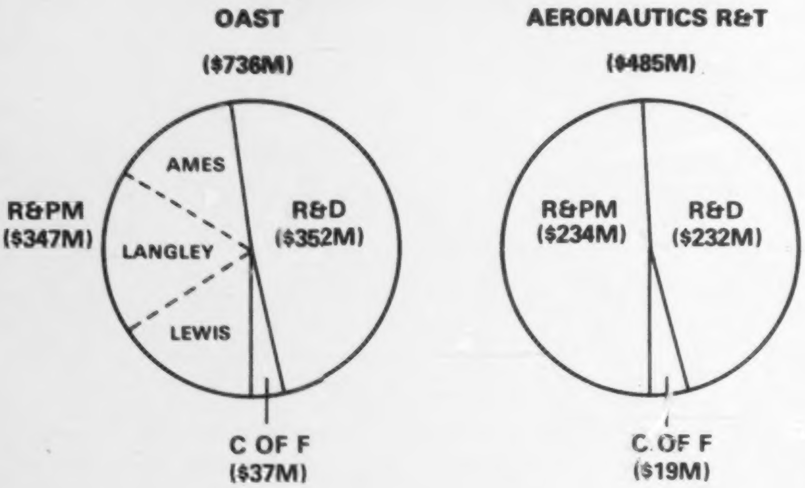

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Figure 5

[The following information was subsequently received for the record:]

Questions of the Committee and the Answers Thereto

Question: Have you assessed the aggregate estimated cost of private industry to carry through the technology demonstration phase? How do the private industry estimates compare to the NASA program run out costs prior to cancellation?

Answer: The following table is a summation of those major programs that are to be phased out by NASA, with estimates of the projected industry costs required to carry them through technology demonstration. Costs associated with the necessary validations, refinement and application to specific designs and/or product development are not included. It is NASA's judgment that the cost of accomplishing the comparable scope of work would be approximately the same whether sponsored by industry or government. However, the projected costs would be incurred by each company choosing to undertake the effort, independently.

Comparison of the estimated costs through technology demonstration with projected NASA program run out costs is inappropriate. The NASA program run out projection can only reflect the approved program, which does not in all cases extend to technology demonstration.

TECHNOLOGY	ESTIMATED INDUSTRY COST THROUGH DEMONSTRATION ($ Million)
Energy Efficient Transport	5
Composite Primary Wing Structure	85
Advanced Turboprop	190
Laminar Flow Control	75
Energy Efficient Engine	10

Question: Could you discuss the Japanese activity in the aerodynamic super computer field? Are the French pursuing this capability in light of their very aggressive and ambitious aerospace activities?

Answer: The Japanese activity in supercomputers is a three-phased government/industry approach to the development of large scientific computers. While there are indications that the Japanese are conceptually planning a large special purpose computer for their National Aerospace Laboratory, they have as yet made no announcement to begin development of such a machine. However, their concerted government/industry efforts to develop the world's largest supercomputers will eventually give their researchers access to computers of greater capacity than any currently planned elsewhere.

Three-Phased Approach

A. Short Term: Company Sponsored Developments

- Hitachi, Pre-Production Stage
- Fujitsu, Developmental Stage
- Nippon Electric, Design Stage

B. Mid Term: Ministry of International Trade and Industry (MITI) Sponsored Supercomputer Technology Research and Development

C. Long Term: MITI Sponsored Computer Science Research

- "Fifth Generation" Computer

The company sponsored developments will lead to the delivery in September 1982, of the first Japanese large-scale scientific computer: the Hitachi HAP-1. Hitachi has announced four sales of the HAP-1 with three additional sales pending. The HAP-1 has a projected performance of approximately twice that of the American CRAY-1 and is reported to be of similar design. The HAP-1 is being offered with a memory of up to 16 million words, approximately twice that of the largest current CRAY computers. The technology used in the HAP-1 appears to be state-of-the-art.

The developments at Fujitsu are somewhat more ambitious with an announced objective of producing performance levels three to five times that of the CRAY-1. The Fujitsu computer is still in the development phase with an anticipated first delivery in 1983. This machine also appears to use state-of-the-art technology and is similar in design to the CRAY-1. Both the Hitachi and Fujitsu machines are reported to be compatible with IBM equipment.

The Nippon Electric computer development is very ambitious in its announced performance goals: speed - 1 billion floating point operations per second; memory - 32 million words. This development is in its very early stages and has a target date for introduction in the 1984-85 time frame. To achieve the performance levels expected, the Nippon Electric machine will have an advanced parallel processing architecture.

The MITI sponsored supercomputer technology development has as its objectives the development of new advanced technology for supercomputers with primary emphasis on advanced electronics, i.e., Josephson Junctions and cooled Gallium Arsenide. The stated long range goal is to develop the technology necessary to construct a computer with a performance level of 10 billion floating point operations per second by 1988. This project began April 1, 1982, with $130 million government funds and $210 million company funds. There are six companies involved in the joint project with the government and Fujitsu serving as the early phase leader. The goals for this project are very ambitious and could result in Japanese preeminence in computer technology.

The last project of the three phased Japanese approach is the so-called "Fifth Generation" computer sponsored by MITI. This is not a single computer development but a system of special purpose computers networked together to produce an extraordinary capability. This "Fifth Generation" project is in reality a broad attack on the computer science research frontiers. The proposed research emphasis is focused through 26 themes grouped in 7 computer science areas. The MITI is proposing to fund the research over the next ten years in three distinct phases: 3 years on fundamental developments; 4 years on subsystems development; 3 years on total system development and integration. The announced funding is $100-$150 million but could go considerably higher. The project is expected to start in 1982 and even if never completed, the research accomplished in pursuit of the goals will give the Japanese a computer science technology lead that could extend well into the 21st century.

The French do not appear to be developing their own supercomputer for they currently rely on commercially available supercomputers produced in the United States. They appear instead to be concentrating on the small "home" computer market since the government recently announced the formation of a research and development agency to pursue the technology of small computers and small computer networking. The announced budget for this new research institute is $20 million per year.

Question: Has DOD shown any interest in the turboprop development? If so, please outline that interest?

Answer: Both the Air Force and the Navy have shown interest in NASA's Advanced Turboprop (ATP) program. A continuing exchange of information and discussion of the technology has been carried on between NASA Lewis Research Center personnel and their counterparts at the Wright-Patterson Air Force Base (WPAFB). On October 26, 1981, General L. A. Skantze and about a dozen technical people from WPAFB, representing the Aeronautical Systems Division and the Wright Aeronautical Laboratories, visited Lewis for an all-day briefing primarily on the ATP program. General Skantze, in a November letter, stated, "we fully endorse your advanced turboprop program and encourage acceleration, if possible. Potential future Air Force applications include a C-130 replacement, a long-range heavy transport with unrefueled round trip capacity and, dependent upon the outcome of mission analyses, perhaps a continuous patrol long endurance aircraft." The Navy has also maintained an interest in the ATP program through occasional visits and inquiries. Their major interest has been in long endurance patrol aircraft, such as those used in antisubmarine surveillance and fleet defense. Both services have made internal requests for study or technology funds, but none have been allocated by DOD.

Question: In regards to the various energy efficient programs, how much of the developed technology can be applied to the global existing transport fleets? How much has already been applied?

Answer: From the outset, certain of the elements of the ACEE program were intended for early application. As such, they were of a nature that could be used to retrofit existing aircraft or engines. However, the major benefits projected for the program were to accrue from technologies that could only be incorporated in a new aircraft design. The following table summarizes the charter and status of each of the ACEE program elements.

Program	Applications	Demonstrated Improvement† (Percent)
Engine Component Improvement	JT8D, JT9D, CF6	5
Energy Efficient Engine	New Engine, CF6-8D PW2037	15
Composite Structures		
Secondary	B-757, B-767	0.75
Primary	New Design	
Advanced Turboprop	New Design	
Laminar Flow Control	New Design	
Energy Efficient Transport		
Aerodynamics	New Design	
Active Controls	(Load Alleviation) L-1011-500	3

† In flight efficiency

Question: What effects will the termination of the primary aircraft composites technology demonstrations have on this Nation's commercial transport market?

-- Would it be feasible to develop this primary aircraft structure technology as part of the R&D effort for the Air Force C-17 program?

-- What cooperation exists between NASA and the Air Force in this area?

Answer: From an economic viewpoint, a composite primary structure on the next generation of transport aircraft promises 10-15 percent reduced gross weight and fuel consumption. Essential to the use of composites technology in primary structures is an independent, fundamental data base of the loading characteristics and interactions, as well as the corollary assurance of a safe operating lifetime. If private industry does not pick up this effort, then U. S. commercial aircraft may not be technologically competitive with their foreign counterparts.

-- Yes, it would be technically feasible to develop this primary aircraft structure technology as part of the R&D effort for the Air Force C-17 program. However, several inhibiting factors would limit the usefulness of the technology produced. The C-17 is a metallic point design and conversion to a composite design would be limiting and non-optimum. Development of a point design by a single contractor would severely limit both the design approaches and the broad use of the data. The constraints of a military development cycle would limit the data output and technology transfer. Technology development to DOD structural criteria, including operational use and fatigue life, would limit their usefulness for civil application.

-- Coordination of NASA/DOD composite programs is maintained through a Composites Interdependency Committee under the Aeronautics & Astronautics Coordinating Board Aero Panel.

Question: What are the current prospects of carbon fiber production in the United States for aircraft carbon composite applications?

Answer: The industry capacity for converting polyacrylonitrile (PAN) precursor to graphite fiber has easily kept pace with existing requirements. Projections are that future expansion of capacity requires 18-24 months lead time. Union Carbide Company has initiated a facility in South Carolina to produce the PAN precursor fiber, which presently is practically all imported from Japan. Hercules Company has made the decision to continue importing from Japan rather than invest in a domestic plant.

Question: What will the effects of aeronautical advanced planning be by decreasing the funds for and distributing the systems studies within the associated research and technology base or systems technology programs?

Answer: The highest priority systems studies can be performed under the planned funding.

Question: What will the projected cut backs in the areas of the fuel efficient transport, engine, turboprop, etc. do to the projected leap frogging in aircraft fuel efficiency from the 10-15 percent regime to the 25-45 percent?

Answer: Based upon continued evolutionary improvements and assuming a constant 60 percent load factor, the average passenger miles per gallon of fuel for the Air Transport fleet can be expected to improve by 25 percent in the next three decades. The technologies developed in the ACEE program to date, if incorporated in the next generation transport aircraft would provide a 30 percent improvement to that baseline. Technology opportunities remaining in Composite Primary Structures, Laminar Flow Control, Energy Efficient Transport and Advanced Turboprop programs could, if exploited, add an additional 30 percent to the total air transport fleet average passenger miles per gallon.

Question: If the NASA primary structure composite work is terminated, will DOD continue the research and development necessary to design, fabricate and test a flight article?

Answer: The remaining effort under the primary structure composite research program that was impacted is associated with work on the large empennage composite primary structure. At present, DOD programs and plans do not include any large empennage composite structures activity.

Question: During the past decades, we have seen various NASA/DOD V/STOL and tilt-rotor programs including the XC-142, XC-15, XC-16, and XV-15 aircraft. However, the only operational craft in this class other than helicopter is the AV-8A Harrier, an English developed close support jet attack aircraft for the U.S. Marines. Can we expect an operational derivative of the XV-15 in the near future for either commercial or military use?

Answer: The tilt-rotor concept is under consideration for application to the Joint Services Medium Lift requirement (JVX) of the Army, Navy and Air Force. The Army is the lead service in this activity.

Question: In the area of human factors engineering as related to an aircraft cockpit, what percentage decrease in gages, displays, switches and knobs per crew member is envisioned as a result of NASA's Human Factors Research and Technology Program? What percentage of this program is slanted toward DOD objectives versus non-DOD objectives?

Answer: The NASA Human Factors program will result in a decrease in the number of cockpit gauges, switches, and dials, as their functions are transferred to electronic displays such as cathode ray tubes and to compact data entry devices such as multi-function programmable keyboards. Both display and command functions may be integrated in a single touch-sensitive flat panel display. Thus, although the number of display and control devices is being reduced, the number of functions and the amount of data available to the crew is increasing. For example, it is possible to put a map, ground track, planned route structure, weather, nearby traffic, and other information all on the same display.

The point is not how many (or how few) displays there are, but how the displayed information is integrated. A related issue, which was brought about by the wealth of new sensors and onboard computational and data storage capability, is when to store data and when to display it. Technology is making it easier to overload a crew. The ongoing work on integrated caution and warning systems is an example of human factors efforts to insure that crews are not overloaded with information.

NASA research on cockpit human factors focuses on the area of transferring information between the crew and cockpit systems. It focuses on the fundamental perceptual and cognitive limitations and capabilities of the crew and on how information can be grouped and displayed so as not to exceed the crew's capabilities. A part of this work is aimed at developing a method of allocating functions to humans and to automation. The goal is to insure that the job is done as safely and efficiently as possible and in such a way that the crew is neither overloaded or underloaded. Overuse of automation can cause problems such as skill atrophy in crewmembers, and difficulty in having the human get back in the loop when an unforeseen problem occurs.

The NASA Human Factors program is researching the circadian desynchronosis area jointly with the Air Force and the Army and is coordinating with the military closely on workload measurement, the role of cockpit automation, simulation technology, and cockpit displays. The focus of NASA's research on fundamental human cognitive and perceptual capabilities and limitations rather than on specific hardware development renders the entire program of value to military as well as to civilian aviation.

Question: With regard to the nonpersonnel tower being developed by NASA, are there FAA funds involved? If so, what percentages and amounts?

Answer: NASA developed an Automated Pilot Advisory System (APAS) that is a low-cost VFR system providing automatic airport and air traffic advisory information at uncontrolled airports. Successful public demonstrations of APAS were completed August 16, 1980, at the Manassas Municipal Airport, Virginia, and a final report on APAS was published in November 1981. Although there was a NASA/FAA Interagency Agreement covering cooperative efforts to develop and encourage operational use of unmanned air traffic advisory and management systems that enhance safety, there were no FAA funds involved in the development of APAS.

Question: What FAA programs is NASA involved in? Please note which programs are joint programs and which are reimbursable programs. Please provide for the record a break out of the FAA reimbursables versus NASA's costs.

Answer: NASA and FAA participate in cooperative research in the following broad areas:

- Aviation Safety
- Human Factors
- Meteorology
- Aircraft Noise
- Air Pollution
- Aviation Fuels
- Rotorcraft
- General Aviation
- Structures & Materials
- Airport/Aircraft Avionics

These areas encompass over 30 specific research programs wherein NASA and FAA coordinate joint research plans, funding and progress. The majority of the cooperative research is of this joint nature while about 20 percent are reimbursable. The FAA reimburses NASA Centers to accomplish research needed to augment the FAA's Engineering and Development efforts. The following summarizes reimbursable research, showing the most recent FAA reimbursements.

PROGRAM	FUNDING APPLIED IN FY 1982	
	FAA†	NASA
	($ Thousands)	
Aviation Safety Reporting Systems	1,250	400
Wake Vortex Alleviation	100	450
Fire Safety		
- Interior materials, modeling	710	630
- AMK	1,115	100
Crash Impact Dynamics	300	900
Icing	100	1,075
Ozone	70	150
Lightning Protection	75	1,400
Emergency Locator Transmitter	250	-

† Reimbursable funds provided by FAA and applied to FY 1982 programs.

Question: The development of natural laminar flow for airfoils for general aviation and commuter aircraft has been transferred from the zeroed out General Aviation and Commuter Research and Technology line item to the Aerodynamics Research and Technology line item.

-- What is the potential annual fuel savings estimated to be for the United States if these laminar flow air foils are developed (in millions of barrels of oil equivalent)?

Answer: Aircraft drag reductions of from 10 to 20 percent are feasible with the full exploitation of Natural Laminar Flow (NLF) technology with corresponding improvements in fuel economy. Full utilization of NLF technology would include not only laminar flow airfoils but also the reduction in powerplant and other aircraft system components due to the reduced drag. If, for example, half of the new aircraft produced from now until 1993 were to incorporate NLF technology, there could be a potential annual fuel savings of from 50 to 100 million gallons. The fuel savings would increase from 1993 on with the increasing use of NLF technology.

Question: What progress has NASA made in developing hydrogen as an alternative fuel for aircraft following the study contracts with Lockheed Aircraft Co.?

Answer: NASA's predecessor, the NACA, conducted liquid hydrogen aircraft engine research over 25 years ago including flight tests. Subsequent NASA studies of LH_2-fueled subsonic and supersonic transports have identified the major potential advantages, technological problems, and comparative cost effectiveness of such transports relative to conventional designs. In a 1979 report prepared at the request of the House Committee on Science and Technology, NASA identified several key technical risk areas associated with the use of cryogenic fuels; one of the most important of which was the issue of safety. To this end, contracts with A. D. Little and Lockheed have just been completed which assess the crashfire hazard of liquid hydrogen fueled aircraft. These reports concluded that "LH_2 does not appear to be a significantly more hazardous fuel than conventional jet fuels and liquid methane. Areas of potential future research involve development of long-life components such as pumps and pump bearings and seals, tanks and insulation, delivery lines and valves for LH_2 service. However, the fact remains that LH_2 fuels remain at present the highest cost option among all of the potential alternative aviation fuel candidates and one not necessarily controlled by engine and airframe technology development but by the economic and institutional factors associated with basic supply issues; i.e., production, transmission, distribution, and storage.

Question: Will the Propulsion Research and Technology mechanical power transfer research be emphasizing turboprop or helicopter applications or any other?

Answer: The Mechanical Power Transfer R&T Base program is providing a broad technology base for far-term rotorcraft, turboprop, and geared-turbofan applications. This research will result in improvements in reliability, life, performance of mechanical components and advanced transmission systems. In addition, the Helicopter Transmission Systems Technology program is evaluating new and innovative transmission concepts and validating advanced mechanical concepts in a system environment. While the principal focus of these efforts has been on helicopter applications, they are providing generic technology for other advanced transmission systems. Although the Helicopter Transmission Systems Technology program funding will end in FY 1982, the continuation and completion of the remaining research efforts will be conducted in the Mechanical Power Transfer program. In addition, the Mechanical Power Transfer program will continue with an increasing emphasis on technology important to turboprop applications.

Question: Is NASA doing any work on communication satellites for air traffic control; either commercial or military?

Answer: No.

Question: Has sufficient progress been made in the materials and structures systems technology program to predict the potential reduction in U.S. dependency on cobalt, chromium, tantalum and columbium?

Answer: NASA does not presently have a Materials and Structures Systems Technology program directed at the conservation of strategic materials. There is an ongoing R&T Base effort which is being conducted at the Lewis Research Center directed at understanding the role of strategic elements, such as cobalt, titanium, and columbium in superalloys. It is expected that once we understand the role of these elements we will be able to develop suitable substitutes for high temperature superalloys. Sufficient progress has not been made at this time to predict potential reduction in U.S. dependency on these elements.

Question: NASA has indicated the continued development of the turboprop propeller in FY 1983. Is it expected that the designs and knowledge from this effort will lead to more efficient propellers which could be retrofitted to the world's current turboprop fleets? If so, what are the projected sales levels expected by the potential market? What will the estimated benefit/cost ratio be to the government?

Answer: The objective of NASA's advanced propeller research effort in the R&T Base is to extend the region of efficient turboprop operation into the Mach 0.7 to 0.8 cruise speed range. Current turboprops in the free world fleet are designed for Mach 0.6 or less. They are very efficient propellers for this speed. Further advances being made by the industry are for noise reduction and reduced weight. Advanced propellers for higher speeds, based on the kind of technology that NASA will be pursuing, would be applied on new turboprop aircraft designed for Mach 0.7 to 0.8. Retrofit to slower, existing aircraft would not be beneficial; therefore, no current market exists.

Question: The Materials and Structures Systems Technology FY 1982 line item has been decreased by $0.5 million from $7.1 million to $6.6 million to reflect the phase down and termination of the integrated program for aerospace vehicle design and the aeroelasticity of turbine engines program. No monies were requested for FY 1983.

-- Does this phase down and termination indicate program completions? If not, why the termination? How does this termination effect our aircraft engine industry, especially the commercial engine industry segment?

Answer: The $0.5 million decrease from $7.1 million to $6.6 million in FY 1982 reflects the following realignment within the Materials and Structures Systems Technology program. The turbine engine hot section technology effort was increased to include critical engine materials research ($1.0 million), and the Integrated Program for Aerospace Vehicle Design (IPAD) and the Aeroelasticity of Turbine Engines (ATE) projects were decreased in emphasis by $1.3 million and $0.2 million, respectively. As originally planned, the ATE program was scheduled for completion at the end of FY 1982 and the last year of funding in the IPAD program was FY 1983. NASA recognizes the importance of the research in data base management and aeroelasticity of turbine engines supported by the IPAD and ATE programs, respectively, and is planning to continue related research in the R&T Base.

Question: How do the refractory type polymeric composite materials being developed by the NASA Lewis Laboratory compare to the current carbon composites used for aircraft applications like tertiary and secondary structural members?

Answer: The refractory type polymeric composite materials being developed at the Lewis Research Center are known as graphite-polyimide composites. The current carbon composites are generally known as graphite-epoxy composites. Both use carbon/graphite fibers as reinforcements; they differ in that one uses polyimide resins, such as PMR-15, as the matrix, where the other uses epoxy resins. The epoxy resins are less expensive and easier to process and, accordingly, are useful for structural applications having use temperature up to 250°F. The graphite-polyimide composites have maximum use temperatures of about 500°F and thus are required where thermal demands exceed the capabilities of graphite-epoxy composites.

Question: What promise do the Lewis polymeric composites have for primary aircraft structure applications?

Answer: The Lewis Research Center polymeric composites are more brittle and more expensive (materials costs and processing costs) than the current graphite-epoxy composites. Otherwise, their promise for primary aircraft structure applications is similar to the demonstrated benefits of graphite-epoxy composites. Polymeric composites are intended for higher temperature applications where graphite-epoxy composites cannot be used.

Question: Considering the high temperature strength properties of the Lewis polymeric composites, what are the possibilities of these materials replacing titanium in the construction of high performance aircraft?

Answer: The Lewis Research Center polymeric composites are currently being evaluated for use instead of titanium in various turbine engine applications. Their prospects for success are high. The benefits are modest weight reductions and substantial cost reductions. The prospects for the Lewis polymeric composites to replace titanium in the construction of high speed aircraft were assessed on a preliminary basis in the Supersonic Cruise Research program and were found to be very good, provided that the fabrication, design and analysis technologies for composite materials in general could be advanced to a level sufficient to satisfy all primary structural requirements.

Question: What will be the effects of the termination of the helicopter transmission systems technology program? Will it have adverse effects on the U.S. Army advanced helicopter development programs?

-- Have nonconventional transmissions; i.e., fluidics, electrical etc. been considered for helicopter transmissions?

-- If so, what were the results of these considerations?

Answer: Funding for the Helicopter Transmission Systems Technology program was originally scheduled to end in 1982. However, the anticipated FY 1982 funding level was reduced by $500,000. Due to the importance and quality of these activities, the important elements of the program will be completed in the R&T Base program. There will be no adverse effect on the Army advanced helicopter development programs.

-- Yes. Nonconventional transmissions such as hydromechanical and electrical transmissions have been investigated. However, analyses have shown them to be heavier and less efficient than conventional transmissions. The Helicopter Transmission Systems Technology program and the R&T Base program are investigating several innovative transmission concepts with potential high payoffs: hybrid traction drive, split torque, and bearingless planetary transmissions are examples.

Question: We noted that the research in alternative fuels programs is stated to be coordinated with and complementary to DOD and DOE programs. Therefore, we would like a presentation for the record outlining these NASA/DOD/DOE programs and how they, in fact, complement each other. Comparative funding levels should be included in the presentation for the record.

Answer:

NASA

The NASA Fuels R&T program, funded at a level of $3.7 million in FY 1982, can be described as follows:

- o Research and technology focused on fuel efficiency/ flexibility for future aviation turbine engines.
- o Generic R&T Base research relating fuel chemistry and property characteristics of fuels derived from various sources.
- o No role in establishing fuel specifications.

DOD

The DOD programs in Fuels R&T totaling $20.4 million in FY 1982 can best be summarized as:

- o Engine test and evaluation of shale oil derived fuels refined to current military specifications.

- Establish fuel specifications, qualification and fuel handling procedures.

- Procurement agent for the Synfuels Corporation.

As with NASA, the Air Force activities ($8.5 million in FY 1982) are strictly focused on aviation applications. Recent emphasis has been on assessing the potential of producing JP-4 spec fuel from various shale oil sources and test and evaluation of the current military engine inventory with these fuels.

On the other hand, the Army and Navy programs (funded at levels of $2.0 million and $9.9 million in FY 1982 respectively) cover the entire "mobility fuels" spectrum and include work on such fuel types as No. 2 Diesel (DF-2), motor gasoline, Marine Diesel (DF-M), as well as aviation gasoline and JP5/JP8.

DOE

The DOE fuels related efforts funded at a level of $4.5 million in FY 1982, can be characterized as follows:

- R&D on extraction, upgrading and refining techniques and processes.

- Development of utilization technologies for stationary power and ground transportation applications.

- Potential source of research test fuels for Government and industry.

The DOE efforts encompassed in the above funding represent only that work associated with transportation applications, specifically the Alternative Fuels Utilization Program. This includes $750,000 for developing a capability to supply research test fuels. Programs which concern the utilization of coal-derived liquids, low and medium BTU gas and fluidized bed combustion for stationary ground power (utility) applications are not included.

Coordination of these fuels R&T activities is an ongoing activity principally accomplished through the Interagency Coordination Group for Government-Sponsored Fuels R&T. The membership of the group consists of representatives from the NASA, Army, Navy, Air Force, and DOE.

Question: Prioritize the twelve Aeronautical Systems technology programs listed in Vol. I of the NASA Budget Estimates for reduction in FY 1982 and termination prior to FY 1983. These programs are listed as follows:

1) Aeronautical system studies
2) Integrated program for aerospace vehicle design
3) Aeroelasticity of turbine engine
4) Helicopter transmission technology
5) Powered lift technology
6) Tilt rotor systems technology
7) Laminar flow control
8) Energy efficient transport
9) Composite primary aircraft structures

10) Terminal configured vehicle
11) Energy efficient engine
12) Advanced turboprop

Answer: These Aeronautical Systems Technology programs have been identified for termination as a result of the President's economic policy of reducing NASA's participation in aeronautical technology demonstrations determined by the Administration to be more appropriate for the private sector to conduct. As a consequence, the twelve Systems Technology programs cannot be rationally prioritized.

Question: With regard to the type of aircraft icing research performed by NASA, what have you done on ice detection systems and system components such as an ice sensor? If such aircraft ice detection subsystems have been developed for commercial aircraft, we would appreciate a summary of their capabilities, their operational experience, and their relevance to the Air Florida crash.

Answer: In FY 1981, NASA, at the Lewis Research Center, conducted icing wind tunnel tests of an innovative microwave instrument designed to detect ice on an aircraft surface and measure its thickness and growth rates. During testing the instrument was installed on an actual airfoil section. It mounts flush on the surface and can be used on any aircraft surface without affecting the aerodynamics. Results of the tests showed that this concept using microwave radiation at extremely low levels (much less than levels established as safe for human health) is theoretically feasible. Additional work and refinement is needed to determine whether or not the concept can be developed as an operational instrument for aircraft.

Also in FY 1981, NASA developed an electronics and software package for an ice accretion instrument developed by NASA in the 1950's and used to measure supercooled cloud properties. The instrument was tested in an icing wind tunnel to evaluate its real-time prediction of the ice growth rate and the liquid water content of clouds. Later in FY 1982 the instrument was evaluated in actual icing conditions aboard the Lewis icing flight research aircraft. Preliminary results indicate it has potential as a real-time icing instrument for aircraft. Work will continue in FY 1983. Neither of these two systems have been used commercially or developed to the point of commercial application.

Currently NASA is acquiring ice detection systems which are commercially available and will characterize them in controlled icing wind tunnel conditions and then evaluate them in actual icing conditions during ice research flights. The studies will begin in late FY 1982 or early FY 1983 and continue until complete. A list of the instruments, parameters measured, their known capabilities to date, and relevance to the Air Florida crash is shown in Chart A. It must be noted that the instruments listed are extremely difficult to calibrate for repeatable results as no absolute calibration standards are available. Both the Leigh and the Rosemount probes are used on some aircraft.

Question: Concerning the applicability of the Numerical Aeronautical Simulator with its potential application to the C-5A wing fatigue life problem, had the computer and analytical capability been available for the C-5A wing design analysis as projected by Dr. Kerrebrock, what corrective costs might have been avoided? How do these postulated corrective costs compare to the development costs of the Numerical Aeronautical Simulator?

Answer: When Lockheed designed the wing for the C-5A they were concerned about performance as part of the new incentive contract policy of the Department of Defense at that time. The more weight that could be removed from the wing, the greater the aircraft range and payload. A wing design program based on minimizing weight was instituted as a major project goal. An accurate definition and understanding of the aircraft load spectrum is required in order to perform detailed structural analysis and associated wing fatigue evaluation. A major problem was the inability to obtain sufficiently accurate aircraft loads at the appropriate high Reynolds number from existing wind tunnel capability. The NAS computer with the associated software could have been used to obtain flow velocities and pressure distributions over the C-5A wing at appropriate Reynolds number. This would then result in an accurate definition of aircraft loads for use in the wing structural analysis and design. The C-5A wing life limitation was due to fatigue cracks at highly stressed fastener holes. If better defined loading spectrums had been available, then local high stress areas could have been located in the wing during the detailed structural analysis and fatigue evaluation. This could have resulted in a minimum weight wing design without reduction in actual wing service life. Because of the cracked wing skins, the Department of Defense is now spending $1.5 billion to re-wing the fleet of 77 airplanes. The Numerical Aerodynamic Simulator development costs are projected as a small fraction of this.

CHART A

Instrument	Parameters measured	Known capabilities and usefulness	Relevance to Air Florida
1. Leigh	Liquid water content of clouds; ice accretion rate.	Used on some helicopters to detect ice and control ice protection systems on the aircraft. lso used for research and certification.	Both instruments can be used to detect ice on aircraft. Judgment must be used in the placement of such detection on an aircraft as ice is not accreted uniformly and judgment is required in the use of the instrument output for its effective utilization.
2. Rosemount	do	Used in research and certification, may be used operationally.	

Senator **Schmitt**. Our next witness is Dr. Stephen Piper, coordinator of aircraft trade policy, Office of the U.S. Trade Representative. Dr. Piper, if you would summarize your testimony and we will have some questions for you.

I would like to congratulate you on your statement. It is very illuminating and we certainly will give you a chance to summarize it before we cut you off and ring a bell so you will salivate for us.

STATEMENT OF DR. W. STEPHEN PIPER, COORDINATOR FOR AEROSPACE TRADE POLICY, OFFICE OF THE U.S. TRADE REPRESENTATIVE

Mr. **Piper**. Thank you very much, Mr. Chairman. In fact, I should like to amend the statement a little bit with information received by diplomatic message this morning from the American Embassies in London and Bonn.

Senator SCHMITT. That certainly will be permitted.

Mr. PIPER. I am pleased to have the opportunity to appear before you and the committee this morning on behalf of Ambassador Brock, the United States Trade Representative, to provide our assessment, first, of the contribution of America's civil aircraft manufacturing industry to our foreign trade position, and, second, of the increasingly competitive situation our industry is encountering in world markets.

America's manufacturers of large transports, helicopters, commuter aircraft, business jets, and general-aviation aircraft, and our manufacturers of civil aircraft engines and components represent a major sector of America's industrial economy, involving thousands of firms all across the Nation, if not in every State, and providing employment for hundreds of thousands of highly skilled American workers.

Total U.S. aerospace exports in 1981 were valued at over $18 billion. Of this amount, civil aerospace exports accounted for 77 percent or a total of $13.9 billion. This $13.9 billion worth of civil aerospace product exports represents 72 percent of total sales of U.S. civil aerospace products, which sales were valued last year at $19.4 billion.

I should note that while last year's exports represented a slightly higher than usual share of total shipments, over the past 6 years more than 70 percent of civil aerospace sales have been for export. Thus, the point I would make, Mr. Chairman, is that our civil aerospace industry—all segments of it—depends heavily upon export markets.

I should stress also that the U.S. trade position depends heavily upon these exports of civil aircraft, engines, and parts. Last year our exports of nonagricultural merchandise were valued at $186 billion—of which aerospace exports accounted for nearly 10 percent and civil aerospace exports accounted for about $1 out of every $12 of U.S. nonagricultural merchandise exports.

In terms of trade balance, I might note that U.S. imports of civil aerospace products in 1981 were valued at about $4.2 billion. Consequently, the net contribution of civil aerospace products to our trade position last year was a positive $9.7 billion.

Mr. Chairman, your letter inviting this testimony did not just ask for the data on the success of America's civil aircraft industry in world markets—success that is expressed in the foregoing data on the industry's contribution to our trade position and success that is demonstrated by the fact that about 90 percent of all civil aircraft and helicopters operating outside the Soviet bloc and the People's Republic of China—about 90 percent—are of U.S. manufacture.

You asked what is our assessment of the future; what is our assessment of the growth of foreign manufacturers in this high-technology industrial sector.

In this regard, Mr. Chairman, the first point I should make is that after nine commercial failures in the production of jet transport aircraft the Europeans have a success in the Airbus program. The Airbus program, funded by Governments since its inception and sustained by Government funding in its early years when there were virtually no orders outside of a few for French and German airlines, is now a very solid competitor—and outselling Douglas and Lockheed combined.

The world's civil helicopter market is intensely competitive. Many of the models being produced are from foreign Government-owned or supported factories.

Some seven new commuter aircraft in the 30- to 50-seat-size range have been announced for introduction over the next 3 years. Only 1½ of these are of U.S. origin. The others come principally from Government-owned or supported programs in Brazil, Canada, France, Indonesia, Italy, Northern Ireland, and Spain. The U.S. domestic market is viewed as the principal market of opportunity for all of these aircraft programs.

America's manufacturers of business jets daily face effective competition worldwide, to include in the United States, from Canada, France, Israel, Japan, and the United Kingdom. Europe is, in their term, "rationalizing" its industry to reduce the competition among European manufacturers in order to be able to compete more effectively with American firms. The Airbus program is but the preeminent example of this so-called rationalization.

In Japan, the Ministry of International Trade and Industry has selected civil aerospace as one of the few industries to be targeted for major Government support in the 1980's as a part of Japan's focus on the development of high-technology industries.

Japan has developed and is carrying out a comprehensive, coordinated plan to establish a major civil aircraft manufacturing capability, to establish, probably within the decade, a world-class industry. And MITI is providing major funding—major funding of the Y-X project producing some 17 percent of the Boeing 767 fuselage, of the RJ-500 engine collaboration with Rolls-Royce, and for Japan's participation in a new generation 150-seat jet transport program—with as-yet-unnamed partners.

Thus, we cannot rest on the trade record to date, nor does our present market position suggest a future position of strength, unless America's industry works hard and effectively to develop new products and to sell them worldwide.

We should have no doubt about the ability of U.S.-manufactured transport, commuter, helicopter, and general aviation aircraft to compete with the best aircraft foreign manufacturers can develop. But the rules of the competition, at home and abroad, must be such that the aircraft compete on their technological merits without the distortion of subsidies and without those trade restrictions that constrain market development.

One might well ask specifically what actions the Government should take to enhance the private sector's ability to compete effectively in the world aviation market. A direct answer to that question would have to include the following on the list of necessary actions.

First, the GATT Agreement on Trade in Civil Aircraft concluded as part of the recently completed Tokyo round of Multilateral Trade Negotiations, establishes an internationally agreed framework for the conduct of trade in civil aircraft, engines and components. It needs effective enforcement.

In some instances, enforcement actions will involve bilateral consultations, as they have already. In others, it will involve formal cases brought before the GATT. The U.S. private sector, as well as the Government, must monitor compliance with the agreements, and together we must prepare well-documented enforcement actions in those cases where we believe our trade rights have been denied or impaired.

Not all aircraft manufacturing countries are party to the Agreement on Trade in Civil Aircraft. We must encourage those who are not signatories to aline their aircraft trade policies with the international standard, at the same time taking account of the trade practices permitted developing countries under the General Agreement on Tariffs and Trade.

Foreign aircraft manufacturers offer a sizable market for U.S. manufacturers of engines, avionics, and other aircraft components. While we seek maximum world markets for airframe manufacturers, we should not lose sight of the competition our component manufacturers face and the value of their foreign sales to them and to the U.S. economy.

The final point I would raise, Mr. Chairman, is that export credit financing subsidized by Governments is a distorting factor in aircraft competition—selection competitions that should be based on the technological and economic merits of the aircraft. We should eliminate this distortion by seeking understandings with our trading partners as to interest rate minima, low maturities and other conditions of finance.

As a part of the overall administration effort to seek reform of official export credit practices, we reached an understanding late last summer on financing conditions for current generation large transport aircraft, an understanding that is within the context of the May 1975 Standstill Understanding on Aircraft Financing in the context of the OECD.

The executive branch is agreed that the next step regarding export credit financing in the aircraft sector should be a common line on commuter-size-transport aircraft, and such a common line should, of necessity, involve all manufacturing countries.

Mr. Chairman, that concludes my prepared statement. I should be pleased to answer any questions you or members of the committee might have.

Senator SCHMITT. Thank you, Doctor. You will, as I indicated, be allowed to amend the statement based on the new information that you have.

Do you really expect the various countries and consortia that have developed to agree to any kind of new export framework when they are obviously gaining on their competitors in achieving the ends for which they were formed?

Mr. PIPER. With respect to export credit financing, yes. I think we can reasonably expect some progress, in part because the size of our market is so great. The United States represents about 45 percent of the world demand for large commercial aircraft, probably 50 percent for commuter aircraft and I would guess business jets would fall in about the same category. We have two-thirds of all general aviation aircraft in the world.

For the next generation aircraft participation in the U.S. market will be more essential for commercial success of the program than has been the case for any past program. We have an opportunity because of foreign interest in selling aircraft in the United States to make our position heard well and hopefully heard effectively.

We are presently involved in negotiations with the Airbus-government partners to discuss export credit financing for large aircraft. Next month we will be having an initial discussion on export credit financing for other aircraft within the context of the OECD in Paris.

Senator SCHMITT. Are you implying that the reason they are interested is because there is a real threat that we may close our market or restrict it?

Mr. PIPER. We have made it plain, Senator, in bilateral discussions, in multilateral discussions and in congressional testimony that the United States intends to enforce the trade laws and the trade measures that we have available to us now to enforce free and fair trade. That message, I think, is getting across.

It is not always well received by all, but I would rather not talk in terms of closing markets. I would rather talk in terms of assuring an openness of markets on a fair trade-free trade basis.

Senator SCHMITT. But that is a two-way street.

Mr. PIPER. Yes, sir.

Senator SCHMITT. So the administration recognizes that the financing arrangements and subsidies in other countries tend to make that trade a one-way street and that you will take whatever steps are necessary to insure that those countries understand that unless unfair practices are eliminated or that there is some compensation for it, they will have problems entering our markets.

Mr. PIPER. That is correct. Last October 28, Ambassador Brock appeared before the House Trade Subcommittee in oversight hearings on trade policy and one of the three principal themes of his testimony on that occasion was the trade distortion impact of subsidized export credits. He underscored there the administration's resolve to deal effectively and appropriately with this trade practice.

Senator SCHMITT. Have you seen any change in the strategies of these nations or consortia in aircraft marketing as a consequence of these kinds of statements by Ambassador Brock and others?

Mr. PIPER. Senator, we have seen increased concern as to what actions Ambassador Brock had in mind and what lies behind the administration's discussion on this subject. I think it is fair to say that there is a greater appreciation of the problem and that there is a greater appreciation by our trading partners of the U.S. position in this regard.

It is probably not profitable at this point to forecast early and complete resolution of these discussions, but I am not pessimistic.

Senator SCHMITT. Well, do these countries and the people you are talking with understand that there is increasing discomfort in Congress over the one-way street that free trade with our supposed allies is taking these days not just in aircraft but in satellites, in agriculture, and many other areas, and that unless they begin to move fairly quickly, the position may be one the Congress establishes rather than the administration.

Mr. **Piper**. Senator, I think it is fair to say that our trading partners are increasingly aware of this and are appropriately concerned about the direction of U.S. trade policy. They were intensely interested in the testimony presented last week by Ambassador Brock before the Trade Subcommittee of Senate Finance.

I think also the recent Senate debate on the export credit war chest bill, Senator Heinz' proposal, underscores this point. Certainly we welcome the Senate's and the Congress interest in resolving this difficult trade problem.

Senator **Schmitt**. Well, doctor, I tell you, our indications are that we are having very little effect so far on these nations. We have not gotten their attention and, if anything, their efforts are becoming more aggressive. They are giving more favorable financial terms. They are giving more indications of subsidy in their home country.

Now in the long run, provided we remove the barriers to competition that exist in this country by our own industry, I do not think that they can compete, but in the short term they are causing and raising havoc with our potential markets.

I do not think they have gotten the message. That is what concerns me because I am a free trader and I think almost everybody on this committee is. However, if these nations do not wake up and recognize that free trade is a two-way street, that competition must be fair and open, and that they have to be willing to compete and win or lose on that basis, then you are going to see congressional action that is going to be very difficult, I think, for the administration not to agree to.

Senator Cannon.

Senator **Cannon**. Doctor, have you communicated to OMB your understanding of the value to the nation of the aviation technology leadership?

Mr. **Piper**. Yes, sir; normal practice is that executive branch testimony is coordinated through the Office of Management and Budget. This statement was submitted to them and previous statements on this subject also. Ambassador Brock has had considerable discussion with with Mr. Stockman and others about the importance, regarding, in terms of export credit practices, of export credit funding, and some of the trade problems that our industries are facing.

Senator **Cannon**. But would you not agree that elimination of systems technology programs to achieve a $65 million budget reduction is being pennywise and pound foolish?

Mr. **Piper**. Senator, respectfully I appear as a representative of the Trade Office and I am not really in a position to make an assessment on the technology budget of NASA.

[The statement follows:]

Statement of Dr. W. Stephen Piper, Office of the U.S. Trade Representative

THE U.S. CIVIL AIRCRAFT MANUFACTURING INDUSTRY: INTERNATIONAL TRADE ASPECTS

Senator Schmitt, Members of the Committee, it is a pleasure to appear before you this morning to discuss the contribution of our civil aircraft manufacturing industry to the U.S. trade position in today's world market and questions related to the increasing competition our industry is facing from foreign manufacturers.

Ambassador Brock appreciated your invitation to testify on these trade matters this morning, but asked that I appear here in his stead. I was the chief U.S. negotiator for the development of the Agreement of Trade in Civil Aircraft during the recent Tokyo Round of Multilateral Trade Negotiations. My current assignment is to coordinate the development and conduct of U.S. aerospace trade policy.

With your permission, I propose to discuss, in order:

The U.S. civil aerospace manufacturing industry, and its contribution to the U.S. balance of trade;

The nature and extent of the foreign competition;

U.S. interests in international trade in civil aircraft; and

Implications for U.S. trade policy.

OVERVIEW OF THE U.S. AEROSPACE INDUSTRY

The following facts regarding the composition of the U.S. aerospace industry, its role in the American economy, and the importance of foreign trade in its long-term viability are pertinent:

Civil aircraft sales represent an important and increasing proportion of the industry's sales of civil, military, and space products combined.

In terms of the dollar value of sales, civil aircraft, engines, and parts totaled $19.4 billion in 1981; the value of comparable military items was $20.7 billion.

Aerospace exports in 1981 were valued at $18.12 billion, an increase of 16.8 percent from 1980, and accounted for nearly 10 percent of all U.S. exports of non-agricultural commodities, and for somewhat more than 11 percent of all U.S. exports of manufactures.

Civil aerospace exports in 1981, accounting for 72 percent of sales were valued at $13.88 billion, an increase of only 4.8 percent from 1980, although 1980 showed an increase of 35 percent over 1979. Summary data on the value of exports are:

1981 EXPORTS BY CIVIL AIRCRAFT PRODUCT SECTOR

	Value of exports (millions of dollars)	Percent increase from 1980	As percent of all civil aerospace exports	Exports as percent of sales
Commercial transport aircraft	7,499	10.7	53.9	76
General aviation aircraft	821	11.1	5.9	29
Helicopters	373	24.7	2.6	65
Other aircraft including used aircraft	357	−27.3	2.2	NA
Turbine engines	759	47.7	5.6	NA
Other engines	45	7.1	.3	NA
Parts, accessories, and equipment	4,030	−8.9	29.4	NA
Total	13,884	4.9	100.0	72

Civil exports accounts for 77 percent of the industry's exports in 1981, and for 85 percent of the industry's exports in 1980.

In the most recent (August 24, 1981) Fortune ranking of America's 50 leading exporters, 5 of the top 10 were either totally or predominantly involved in aerospace production.

Currently 1.2 million persons are employed in the production of airframes, engines, aircraft components, and other aerospace products. Within this group, a large percentage of employees are involved in high technology work, thus enabling U.S. aerospace manufacturers to remain on the cutting edge of a competitive industry.

The R&D activities of the aerospace industry have resulted in major technological innovations which have benefitted not only the commercial sector, but have also had military spinoffs.

The industry is composed of many small companies, as well as the well-known large ones. For example, some 4,200 companies (of which 3,500, located in 44 states, are classified as small businesses) assist in the production of the 4½ million parts of a single $70 million B-747.

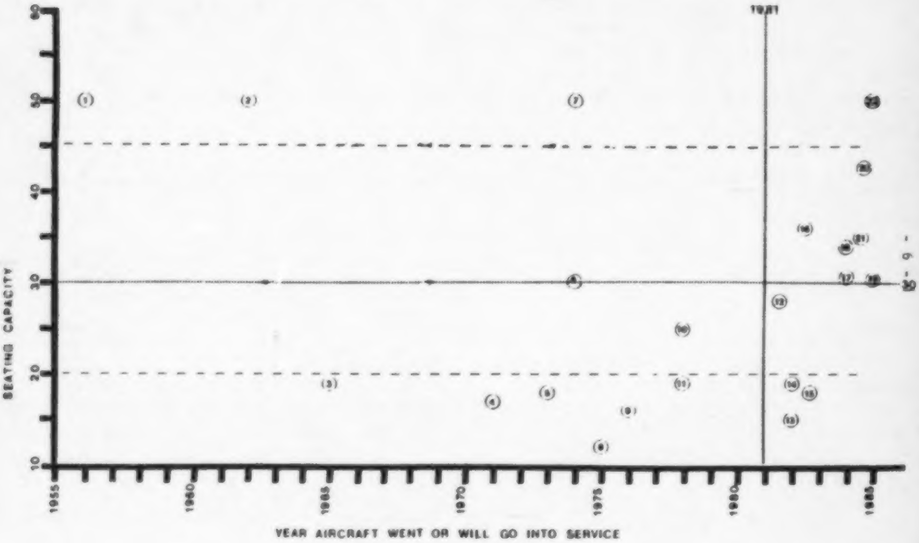
FOREIGN COMPETITION IN CIVIL AIRCRAFT

Commuter aircraft

Foreign manufacturers produce a full range of so-called commuter aircraft—from the 12-passenger Nomad 22B, produced by Australia's Government Aircraft Factories, to the 50-passenger Dutch F-27 and Canadian Dash 7. The scattergram on the next page illustrates the diversity of foreign commuter aircraft programs and indicates the focus of recent developmental efforts in the 30–50 seat range. Most of these aircraft programs have been influenced by sales opportunities in the U.S. market. But note the paucity of U.S. models—only the Fairchild half of the Saab-Fairchild SF-340, the Puerto Rican Ahrens AR-404, and the Commuter Aircraft Corporation CAC 100.

The foreign commuter aircraft seen most commonly in the United States are the 19-seat Twin Otter and 50-seat Dash 7, both from deHavilland of Canada, the 30-seat Shorts 330 from Short Brothers in Northern Ireland, and more recently the Bandeirante from Embraer in Brazil. These aircraft, all products of government-owned or established companies, have in common strong acceptance by U.S. commuter airlines, an acceptance facilitated in most cases by customer financing supported by the Canadian, British, and Brazilian Governments, respectively.

FOREIGN COMMUTER AIRCRAFT IN PRODUCTION OR DEVELOPMENT



LEGEND FOR SCATTERGRAM

1. Dutch Fokker F-27.
2. British Aerospace Corporation Model 748.
3. deHavilland of Canada Twin Otter, DHC-6.
4. Pilatus Britten-Norman Trislander.
5. Brazillian Embraer Bandeirante 110.
6. Short Brothers (Northern Ireland) Shorts 330.
7. deHavilland of Canada Dash 7, DHC-7.
8. Australian Government Aircraft Factories Nomad 22B.
9. Australian Government Aircraft Factories Nomad 24A.
10. Spanish CASA 212-200.
11. Israeli Arava 101B.
12. Puerto Rican Ahrens AR-404.
13. German Dornier 228-100.
14. German Dornier 228-200.
15. British Aerospace Jetstream 31.
16. Short Brothers (Northern Ireland) Shorts 360.
17. deHavilland of Canada Dash 8, DHC-8.
18. Swedish/American Saab-Fairchild SF-340.
19. Brazilian Embraer Brasilia 120.
20. French/Italian ATR-42.
21. Spanish/Indonesian CN-235.

22. Commercial Aircraft Corporation CAC 100.

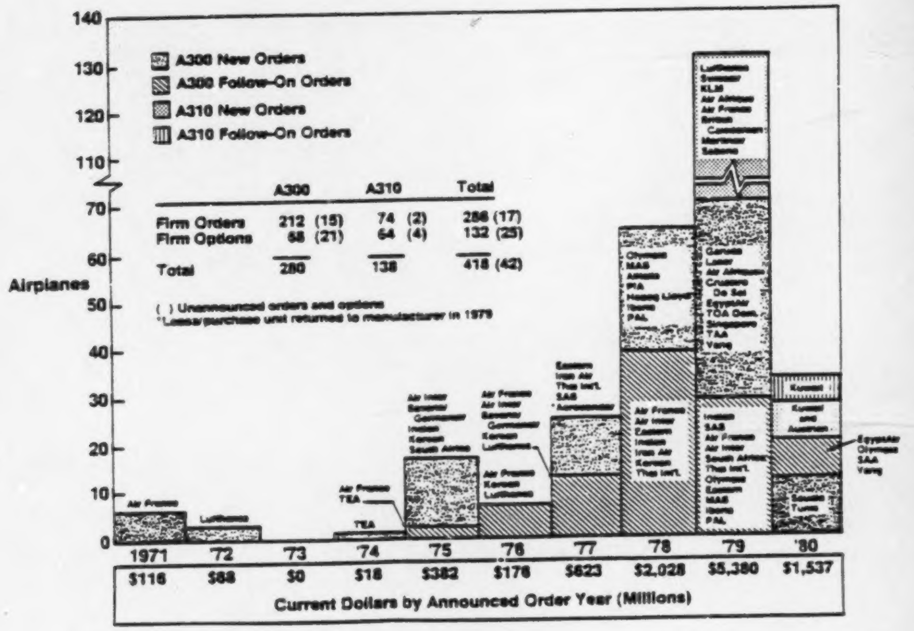
The demand for commuter services and for commuter aircraft represents the greatest growth potential in the present air transport market. Most foreign manufacturers anticipate a worldwide market totalling 1,000 aircraft in the 20–40 seat range through 1990.

I defer to the General Aviation Manufacturers Association and others to testify as to what plans the U.S. industry has to meet this market demand. Foreign manufacturers, I can assure you, are moving rapidly to penetrate all segments of the U.S. commuter aircraft market. In 1979, Embraer of Brazil and deHavilland of Canada each announced new 30-seat aircraft powered by two new-design PT7 Pratt and Whitney of Canada turboprop engines. The Embraer model, called the Brasilia, is due to have its first flight in 1984, with first deliveries in 1985; it will complement the two 18-seat Bandeirante models now in service. The new deHavilland aircraft, designated the Dash 8, is designed for markets for which its 50-seat Dash 7 is too large and its 19-seat Twin Otter is too small. Its first flight is planned for 1983, with deliveries to begin in 1984. British Aerospace, Fokker, and Israel Aircraft Industries are making major new efforts to sell their BAe 748 (50 seats), F-27 (50 seats), and Arava 101B (18–20 seats), respectively, in the U.S. market. Short Brothers is lengthening the fuselage of its Shorts 330 to produce by late this year a 36-seat Shorts 360, with a keen eye on the U.S. market. This program is 6 months ahead of schedule, and in fact, a test aircraft was flown at the Paris Air Show last June.

Large transport aircraft—recent history

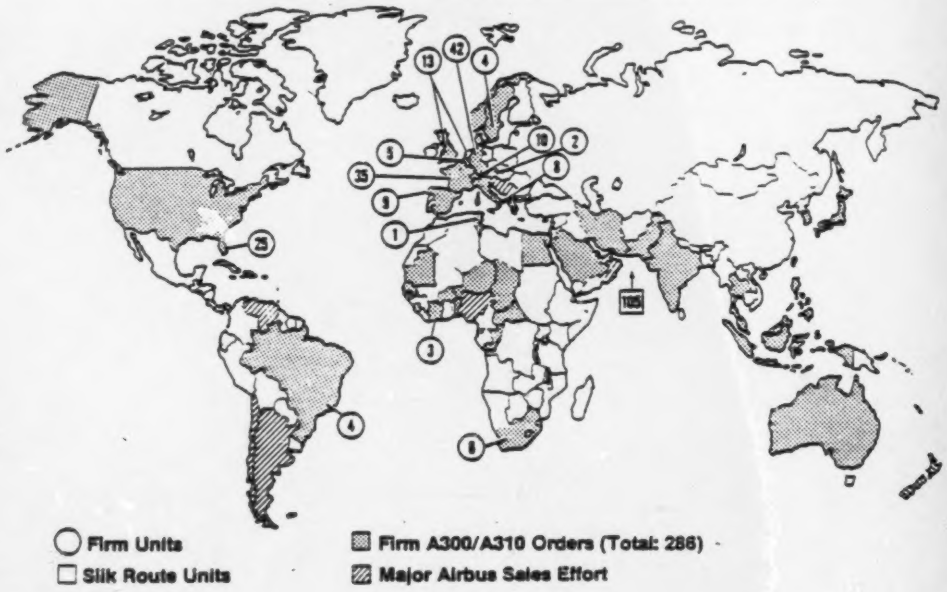
We have become accustomed to seeing U.S. manufactured aircraft—large and small—win the major sales competitions around the world largely because of their economic and technological advantages and because of the quality of service support provided by our manufacturers. Encouraged by the size of the U.S. domestic market (about 45 percent of the non-Soviet world demand for passenger aircraft and two-thirds of the demand for general aviation aircraft), U.S. manufacturers have competed intensely with each other to provide a full range of civil aircraft sizes and types. The strength and diversity of their production base, attuned to the requirements of a multi-faceted market, have aided U.S. aerospace efforts to compete effectively in export markets. The U.S. industry has an outstanding reputation for customer service and has built up extensive product support facilities worldwide. The broad customer base and product support availability have in turn facilitated additional sales to new and repeat customers. While the Europeans have introduced most major innovations in the jet era, our production capacity and technology and our market orientation have resulted in U.S. market dominance. From 1945 to 1948, the Europeans produced 10 different jet transports (a total of 1,088 aircraft—versus 5,218 for U.S. manufacturers), but never more than 280 of one type. All nine programs preceding the airbus were economic failures, largely paid for with government funds. However, with the introduction of the 4-nation Airbus Industrie consortium, the Europeans for the first time have competitive aircraft—both the current A300 model and the new A310, a head-to-head competitor with Boeing's new 767.

A300/A310 Announced Orders and Options
December 31. 1980



A300/A310 World Market Penetration
December 31. 1980

Total Orders and Options to January 19, 1981: 460


13
42
4
10
2
5
35
8
9
1
25
105
3
4
8
○ Firm Units
☐ Silk Route Units
▩ Firm A300/A310 Orders (Total: 286)
▨ Major Airbus Sales Effort

The Europeans, until now, have not been successful in cracking world markets (most of their sales have been mandated procurements by national airlines) and in establishing competitive bases. Here, again, Airbus is different. Airbus is generating a world wide pattern of sales (see figure) and developing prospects for major reorders. Thus, Airbus (with U.S. engines and avionics and with substantial European government support) is positioning itself to obtain a sizable market position in the 1980s. While the U.S. share of the commercial jet aircraft in airline service is 89 percent, the Airbus share of the wide-bodied market, which was 3 percent in 1976, was 38 percent in 1979.

Large transport aircraft—future prospects

But what should be of even greater concern than the market penetration of the Airbus A300 and A310 is the positioning of foreign firms with respect to the much talked about new generation 150-seat jet transport, which would be a replacement for many of the nearly 4,000 older 2-and 3-engine jet aircraft now in service, most of which are of U.S. manufacture.[1]

It is commonly estimated that the investment risk in launching such an aircraft program will be on the order of $1.5–2 billion for the airframe manufacturer and another $1 billion plus for the engine manufacturer. In addition, the negative cash flow position of such a program over the development and early production period can be expected to be as much as $5–6 billion—and this money has to be funded.

Such an initial investment risk, coupled with the very sizable negative cash flow and uncertainly as to the recoupment period (i.e., airline purchase rate) explains why private firms, which risk their own capital and raise investment funds in a competitive market environment, are reticent about launching such a program.

Then there is the aspect of the technological advance, for purchase of such an aircraft is justified by the purchasing airlines on the basis of operating economics sufficiently improved over presently available models so as to justify a capital investment of perhaps $30 million per aircraft, as opposed to some $18–20 million for a B-737-300 or DC-9-80.

Foreign manufacturers do not appear to have the same market-derived restraints placed on them, for they can and do turn to their governments to obtain the risk capital, to fund the cash flow requirements during the development and production periods, and to bear the ultimate risk of production success. The following support this assessment:

The Dutch Government announced it would make available up to $667 million for launching Fokker's F-29, which subsequently became the MDF-100 project with McDonnell Douglas; now terminated. But Fokker can expect much of this funding to be available should it participate in a future project in this category.

The French Government has provided the following funding:

[In millions of francs—current exchange rate about 6.25 French francs per dollar]

	1980	1981	1982
Concorde	115	125	100
Airbus (A300, A310, A320)	623	605	826
ATR-42 commuter	25	25	300
CFM 56 engines	318	452	655
Helicopters	21	17	17
Total authorizations for civil aircraft construction programs	1,223	1,337	2,078

It is significant that in 1980 the French Government provided $107 million for continuing development of the Airbus A310, which is a portion of the total projected French Government share of $548 million (Aerospatiale has a 37.9-percent share in Airbus), while Boeing has had to rely on its own resources and private borrowings at today's market rates to raise the $1 billion plus required to launch the B-767, a head-to-head competitor with the A310.

Much of the 35 percent increase in French funding of Airbus in 1982 will go to development of the 150-seat A320, and that development will be further aided by

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[1] The 150-seat aircraft would be a successor to the B-727 (1,800 ordered, more than 1600 in airline service), B-737-100 and -200 (more than 700 in airline service), DC-9 (all series earlier than Series 80) (more than 900 in airline service), BAC 1-11 (163 in airline service), Caravelle (279 built, 129 in airline service), and Trident (117 built, 86 in airline service).

Air France procurement of the A320, (an order for 50 was announced last June, even though the design was not yet established).

The Government of the Federal Republic of Germany has guaranteed funding of the A300 program to an eventual total of $1.3 billion, although it is not clear that this includes the A320.

The Japanese Government has embarked on a comprehensive program to establish a major civil aircraft manufacturing industry. Indeed, development of such an industry is one of the major elements of MITI's plan for the 1980's.

In 1973, MITI organized the Civil Transport Development Corporation (CTDC)—a consortium of Fuji Heavy Industries, Kawasaki Heavy Industries, and Mitsubishi Heavy Industries—to undertake the Japanese share (17 percent of the fuselage) of the Boeing 767. In fiscal 1981 alone, MITI provided 2,040 million yen ($9.9 million) to pay for half the sum required by CTDC to develop subassemblies for the 767. In fiscal 1982, MITI will provide an additional 395 million yen for this project.

Also in fiscal 1981, MITI provided 4,722 million yen ($22.8 million) to cover two-thirds of Japan's share of the development costs of the RJ-500, a new design 25,000-27,000 pounds thrust engine being developed jointly with Rolls-Royce for the new 150-seat aircraft. Fiscal 1982 funding for this program is set at 5,322 billion yen.

MITI is providing 70 percent of the Japanese industry's expense in market analysis and design studies for the Y-XX project, Japan's 150-seat aircraft program to be done in collaboration with as-yet-unnamed partners.

Japan is using military aircraft coproduction programs to gain aircraft manufacturing technology which is fully applicable to civil aircraft production. For example, Japan will pay $1.8 billion more to produce 90 F-15J's in Japan than it would cost to purchase these aircraft from McDonnell Douglas in St. Louis. This represents a $1.8 billion investment in manufacturing technology. (The GAO has recently completed report ID-82-23, "U.S. Military Coproduction Programs Assist Japan In Developing Its Civil Aircraft Industry.")

Helicopters

Helicopters represent another sector of the civil aircraft industry where the United States has been dominent, but is not finding that dominance challenged, and challenged effectively by foreign manufacturers, especially in France, Germany, the United Kingdom, and more recently Japan. Brazil and Indonesia also have licensed-production programs for helicopters with major European manufacturers.

While for some number of years our manufacturers placed primary emphasis on supplying U.S. Department of Defense requirements, the foreign competition established important inroads in the civil market. As a result, procurement competitions world-wide are now hard fought, as are the competitions for technical developments.

INTERNATIONAL TRADE IN CIVIL AIRCRAFT

From a trade policy perspective, the United States has several interests in the civil aircraft sector. First, as has already been noted, aircraft manufacture is a major U.S. industry and one in which export sales are vital, not only in adding to total employment and sales volume, but importantly in contributing to economies of scale. Export sales account for one-quarter to one-half the activity level for most of our programs, and unit costs are particularly sensitive to volume of production within the range of activity typical of most U.S. aircraft programs. Consequently, the addition of export sales has a substantial effect in lowering the price of aircraft to U.S. purchasers.

Second, U.S. aircraft are technologically competitive with, if not superior to, any in the world; our manufacturing practices are the most efficient. To maintain this position, and to be able to generate the substantial sums of capital required to launch new programs, our aircraft manufacturers must have access to world markets on a competitive basis.

Third, at the same time that we state the need for U.S. airframe manufacturers to have access to world markets, we should note that U.S. component and equipment manufacturers have substantial sales prospects with the many aircraft construction programs being pursued in other countries. We need to take steps to assure that they continue to have competitive access to these market opportunities.

The fourth trade policy interest I would cite is the need to assure that U.S. manufacturers are not confronted with unfair competition from imports within our own domestic market.

Market access

The Agreement on Trade in Civil Aircraft, resulting from the Tokyo Round of Multilateral Trade Negotiations (MTN), has substantially facilitated competition and access in the markets of the nineteen signatories [2] for aircraft, engines, components, and equipment by eliminating all customs duties previously imposed by the signatories on such items. No longer are the selling prices of U.S. aircraft or components increased to take account of customs duties in Canada, Japan, or 15 European countries.

No longer do we impose a five percent duty on commuter aircraft or on other aircraft and aircraft engines from Brazil, Canada, the United Kingdom, or anywhere else outside the Soviet Bloc, a duty that no longer has to be paid by U.S. commuter airlines, or other U.S. purchasers of aircraft and aircraft engines.

But only the 19 signatories to the Agreement on Trade in Civil Aircraft have bound these duties at zero and have pledged not to impose import restrictions on aircraft or parts. Yet other countries such as Australia, Brazil, Indonesia, and Israel manufacture commuter aircraft, and they may impose tariffs or other import charges to the extent such charges are consistent with their obligations under the General Agreement on Tariffs and Trade (GATT).

The GATT does, however, provide special considerations for import restrictions in developing countries, recognizing that they have a need and a right to foster the devlopment of local industries. But there are also limitations on arbitrary resort to such special considerations We are working with a number of countries at the present time in an effort to encourage them to provide a maximum of competitive market access for U.S. aircraft and components.

I might note that the Tokyo Round MTN Agreements on Technical Barriers to Trade (Standards), on Import Licensing Procedures, on Government Procurement, and on Customs Valuation also serve to protect U.S. trade interests with respect to market access for civil aircraft. All of these agreements impose particular limitations on the resort to imposition of non-tariff barriers or discriminatory policies

Fair pricing

Pricing is a second area, after market access, where we we have substantial trade concerns. The Agreement on Trade in Civil Aircraft (Article 6.2) is explicit in stating that the "pricing of civil aircraft should be based on a reasonable expectation of recoupment of all costs." All costs as used here would certainly include the costs or value of governmental assistance, if any, provided for the development, production, or marketing of particular transport, commuter, general aviation, or other aircraft. As in most instances, U.S. manufacturers are competing with government-owned or government-supported companies, the question of assuring that prices cover the costs of governmental support is particularly important—and difficult! Again, this explicit discipline regarding the impact of Governmental subsidies or supports will apply only with respect to aircraft from Canada, the Federal Republic of Germany, France, Italy, Japan, Sweden, the United Kingdom, and the other signatories to the Agreement on trade in Civil Aircraft, but it is an international standard that can be used to measure the performance of others. However, the Tokyo Round of Multilateral Trade Negotiations also produced on Agreement on Subsidies and Countervailing Measures. That Agreement imposes disciplines on both domestic and export subsidies. We can and intend to monitor the practices of signatories to this agreement, which include Brazil, as well as those of signatories to the Aircraft Agreement, to assure that its provisions are being adhered to, and that U.S. trade interests regarding all civil aircraft are not being impaired. The Subsidies Agreement is explicit in noting that a foreign government's production subsidies for aircraft manufacturing could impair U.S. trade interests by causing a loss of U.S. sales, whether in our domestic market, in that manufacturer's home market, or in third country markets.

Competitive sales terms

I have previously noted our concerns with assuring that the U.S. manufacturers of transport, commuter, and general aviation aircraft and components enjoy competitive market access worldwide and that they are not injured as a consequence of subsidies to their foreign competitors. Now I wish to turn to the question of officially supported export credits and their impact on market competitions.

Obtaining effective discipline on official export credit financing for aircraft remains a subject of major concern. In U.S. export markets, the Export-Import Bank of the United States, subject to Congressionally imposed limitations on its level of loan activity, can and usually does provide assistance to U.S. companies in offering competitive financing terms for major sales of new generation large transport category aircraft.

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[2] Signatories to the GATT Agreement on Trade in Civil Aircraft are (as of Apr. 1, 1982): Austria, Canada, Egypt, the European Economic Community (Belgium, Denmark, Federal Republic of Germany, France, Greece, Ireland, Italy, Luxembourg, the Netherlands, the United Kingdom), Japan, Norway, Romania, Sweden, Switzerland, and the United States.

But in the U.S. domestic market, our aircraft manufacturers can find themselves at a competitive disadvantage. Sales of foreign aircraft in the United States are often supported by official export credits provided by the exporting country. For example, the Canadian Export Development Corporation commonly offers financing at an interest rate of 10–11 percent. The United Kingdom also offers attractive financing arrangements for purchases of Shorts aircraft. The purchase of many of the Brazilian Bandeirantes now operating in the United States was facilitated by export credit financing, which typically has the following characteristics: 15 percent down payment, 7½–9 percent interest rate, and 7–9 year repayment term.

U.S. companies, particularly commuter airlines, do not have access to comparable financing terms from U.S. sources. Even the FAA Equipment Loan Guarantee program, which essentially removes the lender's risk, cannot yield competitive financing, nor was it intended to match export credit financing, which typically entails below-market (and therefore subsidized) rates of interest. The competitive disadvantage is particularly serious at a time of high interest rates because of the considerable spread between foreign government supported interest rates of 7½–8½, or even 9–11 percent, and U.S. commerical rates, which even with an FAA guarantee will not be below those of a comparable Treasury bond.

TRADE POLICY DIRECTIONS

We have no doubt about the ability of U.S. manufactured transport, commuter, helicopter and general aviation aircraft to compete with the best aircraft foreign manufacturers can develop. But the rules of the competition—at home and abroad—must be such that the aircraft compete on their technological merits—without the distortion of subsidies and without those trade restrictions that constrain market development.

One might well ask specifically what actions the Government should take to enhance the private sector's ability to compete effectively in the world aviation market. A direct answer to that question would have to include the following on the list of necessary actions:

The Agreement on Trade in Civil Aircraft establishes an internationally agreed framework for the conduct of trade in civil aircraft, engines, and components. It needs effective enforcement. In some instances, enforcement actions will involve bilateral consultations; in others, it will involve formal cases brought before the GATT. The U.S. private sector, as well as the Government, must monitor compliance with the Agreements, and together we must prepare well-documented enforcement actions in those cases where we believe our trade rights have been denied or impaired.

Not all aircraft manufacturing countries are party to the Agreement on Trade in Civil Aircraft. We must encourage those who are not signatories to align their aircraft trade policies with the international standard, at the same time taking account of the trade practices permitted developing countries under the General Agreement on Tariffs and Trade.

Foreign aircraft manufacturers offer a sizable market for U.S. manufacturers of engines, avionics, and other aircraft components. While we should seek maximum opportunity for airframe manufacturers, we should not lose sight of the competition our component manufacturers face, and the value of foreign sales to them and to the U.S. economy.

Export credits, subsidized by governments, are a distorting factor in aircraft competitions—selection competitions that should be based on the technological and economic merits of the aircraft. We should eliminate this distortion by seeking understandings with our trading partners as to interest rate minima, loan maturities, and other conditions of finance. As a part of the overall Administration effort to seek reform of official export credit practices, we reached an understanding late last summer on financing conditions for current large transport aircraft, that is within the context of the May 1975 Standstill Understanding on Aircraft Financing. The Executive Branch is agreed that the next step regarding export credit financing in the aircraft sector should be a common line on commuter size transport aircraft, and such a common line should, of necessity, involve all manufacturing countries.

Mr. Chairman, that concludes my prepared statement. I should be pleased to answer any questions you or members of the Committee may have.

FROM FORTUNE, AUGUST 24, 1981 (p.84) - ANNEX A

THE 50 LEADING EXPORTERS

RANK '80	RANK '79	COMPANY	PRODUCTS	EXPORTS ($000)	FORTUNE 500 SALES ($000)	FORTUNE 500 RANK	EXPORTS AS PERCENT OF SALES %	EXPORTS AS PERCENT OF SALES RANK
1	1	**Boeing** (Seattle)	Aircraft	5,503,800	9,426,200	30	58.39	1
2	●	**General Motors** (Detroit)	Automotive vehicles and parts, locomotives	5,287,100	57,728,500	3	9.16	38
3	2	**General Electric** (Fairfield, Conn.)	Generating equipment, aircraft engines	4,265,000	24,959,000	10	17.09	20
4	●	**Ford Motor** (Dearborn, Mich.)	Automotive vehicles and parts	3,453,000	37,085,500	6	9.31	37
5	3	**Caterpillar Tractor** (Peoria, Ill.)	Construction equipment, engines	3,094,000	8,597,800	33	35.99	3
6	5	**E.I. du Pont de Nemours** (Wilmington, Del.)	Chemicals, fibers, plastics	2,175,000	13,652,000	15	15.93	23
7	6	**United Technologies** (Hartford)	Aircraft engines, helicopters	2,142,593	12,323,994	21	17.39	18
8	4	**McDonnell Douglas** (St. Louis)	Aircraft	2,065,800	6,066,300	53	34.05	4
9	●	**International Business Machines** (Armonk, N.Y.)	Information-handling systems, equipment, and parts	1,615,000	26,213,000	8	6.16	44
10	8	**Lockheed** (Burbank, Calif.)	Aircraft and related support services	1,358,000	5,395,700	61	25.17	8
11	●	**Eastman Kodak** (Rochester, N.Y.)	Photographic equipment and supplies	1,357,029	9,734,303	29	13.94	27
12	12	**Union Carbide** (New York)	Chemicals, plastics	1,240,000	9,994,000	27	12.41	31
13	9	**Westinghouse Electric** (Pittsburgh)	Generating equipment, defense systems	1,192,000	8,514,300	34	14.00	26
14	7	**Weyerhaeuser** (Tacoma, Wash.)	Pulp, logs, lumber, wood products	1,140,000	4,535,814	83	25.13	9
15	10	**Raytheon** (Lexington, Mass.)	Electronic equipment	1,042,000	5,002,088	69	20.83	13
16	25	**Monsanto** (St. Louis)	Herbicides, textile fibers, specialty chemicals	1,026,400	6,573,600	48	15.61	24
17	●	**Dow Chemical** (Midland, Mich.)	Chemicals, plastics, magnesium metal	909,000	10,626,000	25	8.55	39
18	23	**International Harvester** (Chicago)	Construction and farm equipment, trucks	888,000	6,311,804	49	14.07	25
19	●	**Hewlett-Packard** (Palo Alto, Calif.)	Electronic equipment	831,000	3,099,000	120	26.82	6
20	13	**Archer-Daniels-Midland** (Decatur, Ill.)	Soybean meal and oil, wheat, corn	808,941	2,802,011	139	28.87	5
21	14	**Signal Companies** (La Jolla, Calif.)	Trucks, engines, chemicals	803,800	4,285,300	85	18.76	15
22	24	**Dresser Industries** (Dallas)	Oil-field and industrial equipment	703,700	4,016,300	93	17.52	16
23	●	**Ingersoll-Rand** (Woodcliff Lake, N.J.)	Drills, compressors, pumps, bearings, tools	702,500	2,970,960	129	23.65	10
24	16	**Philip Morris** (New York)	Tobacco products	702,400	7,328,300	45	9.58	35
25	20	**Deere** (Moline, Ill.)	Farm equipment	688,000	5,469,825	60	12.58	30
26	●	**Mobil** (New York)	Lubricating oils	683,000	59,510,000	2	1.15	48
27	18	**Kaiser Aluminum & Chemical** (Oakland, Calif.)	Aluminum	676,300	3,222,100	114	20.99	12
28	17	**Occidental Petroleum** (Los Angeles)	Agricultural chemical products, coal	651,000	12,476,125	20	5.22	46
29	19	**Textron** (Providence)	Helicopters, machine tools, metal products	636,000	3,637,500	102	17.48	17
30	11	**Northrop** (Los Angeles)	Aircraft and related support services	614,600	1,655,400	219	37.13	2
31	●	**Exxon** (New York)	Petroleum and chemicals	593,000	103,142,834	1	.57	50
32	●	**Aluminum Co. of America** (Pittsburgh)	Aluminum	588,900	5,147,600	63	11.44	34
33	33	**Celanese** (New York)	Fibers, chemicals	576,000	3,348,000	107	17.20	19
34	22	**FMC** (Chicago)	Industrial and farm equipment	558,517	3,482,183	103	16.04	22
35	15	**Rockwell International** (Pittsburgh)	Electronic, automotive, and industrial equipment	543,000	6,906,500	46	7.86	41
36	21	**R.J. Reynolds Industries** (Winston-Salem, N.C.)	Tobacco products	535,300	8,449,000	35	6.34	43
37	43	**International Minerals & Chemical** (Northbrook, Ill.)	Potash, phosphate, industrial minerals	463,700	1,789,600	201	25.91	7
38	●	**Digital Equipment** (Maynard, Mass.)	Computer systems and equipment	453,814	2,368,045	162	19.16	14
39	●	**Sperry** (New York)	Computer systems and equipment	453,213	4,785,425	77	9.47	36
40	28	**Williams Companies** (Tulsa)	Phosphate products, fertilizer	444,000	2,072,686	181	21.42	11
41	●	**NCR** (Dayton, Ohio)	Mainframe computers and terminal systems	426,621	3,322,370	108	12.84	29
42	26	**American Motors** (Southfield, Mich.)	Automotive vehicles and parts	421,579	2,552,587	155	16.52	21
43	31	**International Paper** (New York)	Pulp and paper products	411,000	5,042,900	67	8.15	40
44	●	**Phillips Petroleum** (Bartlesville, Okla.)	Petrochemicals, natural gas	374,000	13,376,563	16	2.80	47
45	47	**Emerson Electric** (St. Louis)	Electronic components	371,783	3,066,841	124	12.12	33
46	29	**Allied Chemical** (Morristown, N.J.)	Fibers, plastics, chemicals	369,000	5,519,000	59	6.69	42
47	●	**Control Data** (Minneapolis)	Computers and peripheral equipment	361,900	2,765,600	141	13.09	28
48	●	**Minnesota Mining & Manufacturing** (St. Paul)	Industrial, health-care, graphics, electronics products	361,000	6,079,540	52	5.94	45
49	●	**Standard Oil of California** (San Francisco)	Chemicals, fuel and gas oils	359,000	40,479,000	5	.89	49
50	●	**AMAX** (Greenwich, Conn.)	Molybdenum, nickel, and phosphate products	357,330	2,949,170	131	12.12	32
		TOTALS		57,277,720	595,858,158			

● Not on last year's list.

Office of the U.S. Trade Representative,
Executive Office of the President,
Washington, D.C., April 1, 1982.

Hon. Harrison H. Schmitt,
Chairman, Subcommittee on Science, Technology, and Space,
U.S. Senate, Washington, D.C.

Dear Mr. Chairman: As promised at this morning's hearings, I am forwarding for your information the content of two telegraphic messages received this morning from the American Embassies in Bonn and in London, as they are timely updates of my prepared testimony.

FROM THE AMERICAN EMBASSY, BONN

"On March 24, 1982, the Federal Cabinet decided to increase the present DM 2.85 billion loan guarantees to DM 4.1 billion, to secure the continuation of construction through 1992 of the A-300 Airbus and the development and construction of the smaller A-310 version. Up to 1992, a production of 860 A-300 and A-310 aircraft is planned at a maximum rate of 8 aircraft per month.

"Furthermore, the Cabinet decided to provide through 1985 additional repayable support of DM 165 million for the development of the advanced version A-300-600, which will replace the present A-300 aircraft model in 1984. To improve the business results of the German section of Airbus Industries Co., the repayment of previous guarantees of DM 2.45 billion will be suspended.

"The Federal Government will provide additional DM 288 million in financing support for 48 aircraft, corresponding to DM six million per aircraft to assist in marketing the wide-body aircraft on the international market against strong competition of the U.S. aircraft. Financing assistance for the Airbus will now total DM 2.044 billion through 1985. Beyond 1985, the support per aircraft is intended to be limited to DM four million, or an additional DM 2.4 billion for another 520 aircraft up to the year 2004.

"According to a DPA/VWD press release, the financing support will be used largely to cover interest subsidies and to counteract strong U.S. financing support by the U.S. Exim Bank."

FROM THE AMERICAN EMBASSY, LONDON

"British Aerospace (BAe) Chairman, Sir Austin Pearce, announced on March 30 that HMG (Her Majesty's Government) had agreed in principle to provide launch aid to BAe for participation in the proposed Airbus A-320 150-seat aircraft. BAe has yet to make detailed financial proposals to HMG, but the conceptual framework under consideration involves either BAe's traditional 20 percent role in Airbus or an increase to 30 percent for this project. This would involve sums presently estimated at 400 and 600 million pounds respectively. With the smaller sum BAe involvement would be confined to the wings; with the larger amount it could take on forward fuselage and flight deck work, according to the Financial Times. Hopefully, Pearce indicated, negotiations with the government would result in firm financial decisions by summer 1982.

"Pearce's statement was made in the context of releasing BAe's accounts for 1981, the first full year since privatization of the firm, the UK's dominant air frame undertaking with extensive military and civilian aeronautical projects as well as missile and space activities. The accounts show a pretax profit of 71 million pounds, up almost 18 million from 1980. An allowance for future losses of 20 million pounds has been made, including about eight million pounds for BAe's share of the aborted Airbus sales to bankrupt Laker Airways. BAe's orderbook across the board shows about two years of work on hand, but the enterprise is being hit by a slowdown in military sales notably the Toronado project and the uncertainties of its civil business. BAe's major civil project of the moment is the 146 feeder jet (in partnership with AVCO-Lycoming of the United States) and its present results are termed disappointing. Only 10 sales and 12 options are on the books at the moment.

"Comment: A certain number of layoffs in the UK aeronautical industry, including 1200 in BAe, have been announced in recent weeks. Our information, from trade association sources, is that these layoffs primarily relate to the military side of the British industry. The civil manufacturing side is perceived as relatively healthy or at least holding its own although no detailed analysis of the balance appears available.

"Pearce's announcement about the Airbus A-320 was somewhat surprising as our information had been that government agencies were reluctant to provide launch aid and were maintaining that BAe would have to finance involvement in this project from its own resources. This reluctance was reflected in the analysis by the Times (London) business editor, in the March 31st edition, when he noted that Pearce at the previous day's press conference could scarcely conceal his annoyance at HMG delays in this matter. It thus remains to be seen whether HMG will really become a partner in the A-320 venture, in what amount, and on what timetable. The absence of a truly suitable new engine for this proposed aircraft weighs heavily on the minds of government officials who have also to consider the extent of HMG involvement in the Rolls Royce-Japanese RJ-500 jet engine (which could power the A-320) in the midst of so much uncertainty regarding airline intentions respecting this size aircraft."

Respectfully yours,

W. STEPHEN PIPER,
Coordinator for Aerospace Trade Policy.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. Based on your experience and knowledge, could you please elaborate in detail on the strategies of other nations with respect to the aircraft market, with examples if possible.

Answer. Elements of foreign strategies for the development of a civil aircraft manufacturing industry and the production and marketing of particular models of aircraft can be described in five broad categories: Government organization of the industry; government funding and support for developing the industry; learning from others through coproduction; government support of manufacturing programs; and government assistance in marketing.

I shall elaborate on these strategy elements, in the course of providing illustrative examples in the following paragraphs. Not all foreign aircraft programs use all of these strategy elements, but all foreign programs depend significantly upon one or several of them.

INDUSTRY ORGANIZATION

The member states of the European Economic Community in recent years have focused increasing attention on the "rationalization" of their aerospace industries. This rationalization effort has had two objectives. First, to reduce, and if possible, to eliminate, intra-European competition in large commercial jet aircraft; and second, to produce a wider range of aircraft to enable European manufacturers as a group to compete with U.S. manufacturers across the broad range of demand for aircraft, not just in particular market segments. The past two decades have seen the amalgamation of numerous private companies into nationalized firms, whose sales and employment policies are set by government ministries, and the further combination of these nationalized entities into transnational organizations for specific projects such as Airbus.

The first stage of "rationalization" was the combining of private firms within individual countries, particularly within France and the United Kingdom, and more recently within the Federal Republic of Germany. For example, in the jet era in Britain, Hawker Siddeley produced the world's first commercial jet transport, the Comet, in 1952. Hawker Siddeley was nationalized in 1977 and made a part of British Aerospace Corporation (BAC), which had been set up as British Aircraft Corporation in 1960 to merge Vickers-Armstrongs (manufacturer of the VC-10), Bristol Aircraft and English Electric Aviation. Also in 1960, BAC acquired the Hunting Co., designers of what came to be (in 1963), the BAC-111. That same year, de Havilland, Blackburns and Follands, airframe manufacturers, were combined into Hawker Siddeley, and Britain reorganized its six aircraft engine manufacturers, leaving intact Rolls-Royce and combining five others into Bristol-Siddeley.

In France, the industry is now centered on two government-owned firms, Aerospatiale (airframes and helicopters) and SNECMA (engines), and on Dassault, which is being nationalized by the present French Administration.

The second stage of "rationalization" has been the replacement of national aircraft projects by international projects such as Concorde, Airbus and the program known for a time as the Joint European Transport (now evolved into the Airbus A-320 proposal) and a conscious effort to avoid development of competitive programs within Europe.

Rationalization of competition among national firms has also been the experience in Japan, where the government established the Nihon Aeroplane Manufacturing Company (NAMC), a special corporate body to carry out the development program for the YS-11 medium-size (64-seat) transport aircraft, which first flew in 1962. Both the government and private firms invested in NAMC, with the former bearing the financial risk. Subsequently, the Ministry of International Trade and Industry (MITI) has aided the organization of the Civil Transport Development Corporation (consisting of Fuju Heavy Industries, Kawasaki Heavy Industries, and Mitsubishi Heavy Industries), which has been established to coordinate Japan's participation in the Boeing 767 program. (Japanese firms are manufacturing fuselage panels, and other components, accounting for about 17 percent of the airframe.) MITI has sponsored the establishment of the Japanese Aero Engine Corporation (consisting of Fuji Heavy Industries, Ishikawajima-Harima Heavy Industries, and Mitsubishji Heavy Industries) in order for Japan to be a 50-50 partner with Rolls-Royce in development and production of the 25,000-27,000 pound thrust turbofan engine for use on a new 150-seat commercial jet transport.

FUNDING AND SUPPORT FOR INDUSTRY DEVELOPMENT

Whereas the Europeans, and to a considerable extent, the Japanese, have strengthened the competitive posture of their national industries by reducing duplication of effort among national firms, we find in a number of cases the establishment of an industry as a matter of national economic or industrial policy; for example, in Brazil, Indonesia, Israel, and Japan. MITI states the case well in its "Vision of MITI Policies in the 1980's," published March 17, 1980:

Since the establishment of economic security is one of the most important priorities for the 1980's, Japan's economic growth must be sufficient to meet the following requirements: Japan must emphasize investment in * * * technological development. . . .

Government action will be required mainly in the following areas: technological development demanding large amounts of funds, incurring high-risks, and needing long lead times. . . .

Technological innovation is a source of progress to Japan as well as the world. Great expectations are therefore placed on technological innovation providing the key to the solution of various problems in the 1980's. Japan must strive to develop its creative capacity and contribute, as an innovator, to world progress.

As technological development is a means of attaining economic security by strengthening a country's bargaining power, Japan must stand on the ground of technology.

The now prevalent apprehension is that technological progress is about to stagnate. In the 1980's, however, the following types of technological efforts will be made (a) new application and combination of existing technologies, (b) flowering of new technology resulting from a new application of science and technology, and (c) the preparation for the next generation's epoch-making technological innovations expected in the years after 1990. If these efforts are successful, the economy and society are expected to move into a new prosperous stage.

The principal role of the government policy for the development of technology is to encourage development efforts in the private sector. . . .

Technological developments must be promoted by presenting a "Long-Term Vision for Technological Development," which identifies the priority goals for technological development, as well as systems for development and funding. . . .

Efforts must be made to increase the budget available for research and development of technologies.

The share of government expenditures for R&D * * * should be raised in spite of the expected deficit in the national budget.

Recognizing that research and development of technologies are the nation's best interest, the government must make every effort to find a new source of funds for financing such projects. . . .

Joint research projects, in which all participating countries contribute their achievements, will be most effective * * * for the development of large-scale technologies (e.g., aircraft and marine exploitation). . . .

Extremely large-scale technologies—new energy, development of sources, aviation and space, and information processing—form the basis for long-term economic progress.

The ability to develop original technology must be fostered through the cooperative efforts of the government and private sector, and international joint projects

The government must take the initiative in development and basic experimental research in high-risk fields.

Brazil and Indonesia are each building major civil aircraft manufacturing industries, focused on government established companies—Embraer and Helibras in Brazil, and Nurtanio in Indonesia—as an element of national economic and industrial development policy. In three year's time, both Embraer and Nurtanio will begin deliveries of commuter aircraft—the 30-seat Embraer Brasilia and the 35-seat CN-235 (in partnership with CASA of Spain), respectively.

COPRODUCTION/TECHNOLOGY TRANSFER

An important element for the development of aircraft industries in a number of countries is coproduction or licensed production, which facilitates advancement along the development/production learning curve. Examples of the use of this strategy are provided by Brazil, Indonesia, and Japan, among others.

Embraer in Brazil began major civil aircraft production activities by assembling six models of Piper aircraft; it now produces three models of Brazilian design.

Nurtanio was launched with licensed production programs for the C-212 Aviocar (from CASA in Spain), the BO-102 helicopter (from MBB in Germany), and the Aerospatiale Puma helicopter (from France). Nurtanio is now in a partnership with CASA to develop and produce the 35-seat CN-235 commuter transport.

Japan has had major licensed production programs for the F-4, F-15, P-3C, among others, which substantively develop the knowledge basis for aircraft manufacture, as well as participation in the Boeing 767 program, and in joint development of the BK-117 helicopter (with MBB), and the RJ-500 engine (with Rolls-Royce). The recent GAO report, "U.S. Military Coproduction Programs Assist Japan in Developing Its Civil Aircraft Industry," (ID-82-233, March 18, 1982), expounds this point.

MANUFACTURING SUPPORT

Most, if not all, governments with an aircraft manufacturing industry maintain some type of government research laboratory and government funded program for aeronautical R&D. In most instances the results of such research become known throughout the world's aeronautical engineering community, and successful concepts are implemented in the aircraft programs of many countries. Aeronautical R&D programs and technology development in the military area also aid civil aircraft developments, and conversely—not only in the United States, but also in all countries with manufacturing industries.

But where the U.S. industry finds itself at such a competitive disadvantage is in the area of funding for the development and production of specific models of aircraft. Foreign programs are commonly aided by the provision of government equity, grants, loans, or loan guarantees.

Aerospatiale (France), Aeritalia (Italy), Canadair (Canada), CASA (Spain), Government Aircraft Factory (Australia), Israel Aircraft Industries, Nurtanio (Indonesia), Rolls-Royce (United Kingdom), Shorts Brothers (United Kingdom), and SNECMA (France) are all government-owned, and so have government-supplied equity. (British Aerospace is now only half-owned by Her Majesty's Government, half ownership having been sold to the public a year ago.)

As indicated in my prepared statement, the French Government regularly appropriates funds to Aerospatiale and SNECMA for specific projects. While there are provisions for recovery of these appropriations, the repayment rate is very slow, and there is no provision for payment of interest on the funds advanced.

The French authorizations for Aerospatiale committed through the end of 1981 for the present Airbus A-300 B2 and B4 models, their improvements, the development of the A-310 and of the A-300-600, total 3,690.5 million francs ($615 million at today's rate of exchange, which considerably understates the dollar value of the support, as during much of this period the exchange rate was 4-5 francs per dollar), of which 826 million francs ($37.7 million) are provided in the fiscal year 1982 budget. In addition, SNECMA has received 100 million francs ($16.7 million) to permit the necessary industrial investments for production of approximately 27 percent of General Electric's CF6-50 engine for the Airbus A-300 and A-310. (SNECMA has received additional funds (1,425 million francs ($238 million) in the fiscal year 1980-82 period) for its share of the GE-SNECMA CFM56 turbofan engine.)

French budget documents indicate that the assistance paid to Aerospatiale and SNECMA are covered by agreements which stipulate reimbursement of these funds (without interest) to the government. However, of the 1,664 million francs paid to Aerospatiale before 1976 for the development of the first A-300's, only 11.9 percent

(198.8 million francs) had been repaid as of July 31, 1981. The budget submitted last fall to the French Senate states that the remaining 88.1 percent of the funds advanced prior to 1976 "shall most probably be reimbursed before 1985," but there is no assurance, and apparently no contractual obligation, that these funds be repaid by 1985 or any other specific date.

The German government has provide DM 2.365 billion in credits to Deutsche Airbus for the development of the A-300, A-310, and A-300-600, of which DM 165 million has just been provided in recent months. The government also assists Airbus production by providing government guarantees to support the private financing of the production operation. This level of guarantees for private financing was increased in March 1982 from DM 2.85 billion to DM 4.1 billion, to support an increase in Airbus production.

Also, in March, the German government deferred repayment of the government credits advanced (interest free) to Deutche Airbus for Airbus development. Under the original arrangement, Deutsche Airbus would have been required to start paying back to the government development credits after the production of the 150th aircraft. Now that repayment is not to begin until some unspecified greater number of aircraft have been produced or until Deutsche Airbus has become profitable.

Brazil aids the capitalization of Embraer by granting tax credits to industrial firms which purchase equity positions in Embraer.

The Canadian Government has given Pratt & Whitney of Canada a C$50 million grant to aid development of the new PW100 turboprop engine for commuter aircraft, among which is the de Havilland Dash 8. The Canadian Government has also provided guarantees for de Havilland's borrowings of the C$450 million needed for development and launching of the 30-seat twin-turboprop Dash 8 commuter aircraft.

In February this year, Canadair, wholly-owned by the Government of Canada since 1976, sought to raise $150 million for a five-year period to support its production of the twin turbofan Challenger business jet. These notes are to be guaranteed as to payment of principal, redemption premium, if any, and interest.

The fiscal year 1982 budget of Japanese Aero Engine Corporation for the RJ-500 project has been set at 8,947 million yen ($38 million), of which 4,942 million yen ($25 million or 66 percent) is to come from the government, and the remainder from the three private companies which constitute Japanese Aero Engines. MITI is also in fiscal year 1982 providing another 1,488 million yen ($6.3 million) for the Y-XX project, which is Japan's analysis of the world market for a new 150-seat commercial jet transport and investigation as to possible partnership arrangements with Boeing, Douglas, and Airbus. While MITI has been funding the Japanese industry's exploration of a 150-seat transport for several years, Boeing and Douglas have had to use their own funds to conduct market surveys and develop aircraft proposals.

Boeing, Douglas, Airbus, Fokker, and the Japanese are major competitors for the next commercial jet aircraft program—a 150-seat twin engine, short-medium range, successor to DC-9 and B-727 type aircraft (of which some 3,600 are in service.)

The stakes are high, as the demand will likely be for at least 600-1,000 such aircraft—at $30-32 million (1982 dollars each)—over the next 10 years. (Such an aircraft would offer a 30-50 percent reduction in seat-mile operating costs over present aircraft, whose basic designs were established twenty years ago.) But only one or perhaps two models in this category can be economically successful.

The risks are high as well, with $2 billion being a common estimate of the investment required to launch the airframe, with another $1 billion investment being required for engine development.

Airbus, like Boeing, is bringing out a new 210-seat aircraft this year, and would likely have difficulty in launching yet another program. Airbus can only launch a new aircraft type with the aid of the massive government funding, and there is now a serious prospect that Airbus will use government-provided funds to launch a new 150-seat aircraft designated the A-320.

France has authorized government funding of 826 million francs ($132 million) for Airbus production in 1982, a 36 percent increase from 1981 funding levels, much of which can be allocated to A-320 development.

British Aerospace Corporation is said to be seeking government funding of 400-600 million pounds ($720-1,080 million) for a 20-30 percent share in A-320 development and production.

The Canadian Government is considering providing some C$550 million to fund Canadian industry participation in the A-320.

In addition to the initial investment, which is totally at risk, an aircraft manufacturer can expect to reach a negative cash flow position of $3-4 billion for each new model while tooling up for production. With the world's airlines now all in a weak financial position, and indeed stretching out, if not cancelling, aircraft orders, private manufacturers are most reluctant to commit now to a new four-year multi-billion dollar aircraft development program. For example, in May 1981, McDonnell Douglas and Fokker formed a partnership to launch a 150-seat airplane (for which the Dutch Government was willing to provide $667 million), but, due to a lack of sufficient market response, they dropped the project nine months later.

MARKETING ASSISTANCE

Foreign manufacturers often find that they can use their national airlines (also for the most part government-owned) as captive customers. The most dramatic example is of course that of Concorde, for which the governments are providing extra operating subsidies to the airlines in order to get them to use the aircra But there are numerous other examples:

Air France held no competition for 210-seat wide-bodied transports; it bought the Airbus A-310, without even considering the competitive Boeing 767.

When Air France announced its preference for Pratt & Whitney engines for the A-310, SNECMA protested, and after two ministerial level reviews and some months of controversy, Air France "decided" to order General Electric CF6 engines instead, because of the greater identification of SNECMA with that engine—SNECMA produces some 27 percent of it, and is in a 50-50 partnership with General Electric for the CFM56 program.

When the president of Air France announced the final selection of the CF6-50 for Air France A-310's, he said that Air France would always buy French aircraft/engines when available.

Air France is switching its fleet of Boeing 747's from Pratt & Whitney engines to General Electric's, again because of the SNECMA connection.

For an airline to use two engine types for the same basic aircraft type in the fleet is quite unusual. The one previous example was British Airways' original purchase of Pratt-owned Boeing 707's and 747's, latter switched to Rolls-Royce engines, when they became available.

de Havilland of Canada chose the PW100 (from Pratt & Whitney of Canada) for the Dash 8, without considering General Electric's competitive CT7.

At the June 1981 Paris Air Show, Airbus announced that Air France has ordered 50 new 150-seat A-320 aircraft with SNECMA-GE engines, even though the airframe design was not established, the manufacturing participation unknown, and the engine program not yet committed by the engine manufacturer.

Neither Air France nor British Airways could obtain government approval for purchase of the Boeing 737 until their Caravelles and Tridents, respectfully, had to be replaced.

To some extent, all governments provide support for aircraft sales, as a component of their export promotion program. As sales of large transport aircraft or even fleet sales of smaller aircraft are relatively few in number and have a large dollar value, some governments are particularly intense in providing political support to their marketing efforts—political support sometimes to the point of pressure.

Question 2. Could you elaborate on your views with regard to the impact of our financing arrangements on our industry, especially with regards to export credit funding. What steps is our industry taking to compete?

Answer. There are two aspects to the question of arrangements for the purchase financing for civil aircraft: financing for sales in the United States and financing for sales outside. U.S. airlines and manufacturers arrange their own financing, often taking advantage of various tax provisions to reduce the financing cost or cash flow requirements associated with the purchase of fleets of $18-80 million aircraft, and for smaller fleets of $1-5 million commuter aircraft and helicopters. Oftentimes financing is arranged over the useful life of the aircraft, and a number of funding sources (commercial banks, investment banks, insurance companies and pension fund, equity market) are tapped to provide financing for a single transaction. But all such funding is at market-determined cost levels, and without the benefit of U.S. Government support (N.B., while tax provisions and in a few cases the FAA Equipment Loan Guarantee Program (the latter especially for commuter aircraft) may be considered forms of Government assistance, they are equally available with respect for foreign-origin aircraft-origin aircraft being sold in the United States.)

To extent that foreign aircraft are offered for sale in the United States with subsidized (i.e., below-market cost) export credit financing, U.S. manufacturers are at competitive disadvantage. Such export credit financing is a trade-distorting subsidy, one that is contrary to the GATT Agreement on Subsidies and Countervailing Measures. Further, if there is injury or threat of injury, such subsidized financing is actionable under U.S. countervailing duty laws.

To illustrate the impact of financing subsidies on an airline, consider a single $50 million airplane financed for 14 years at 12 percent and at 15 percent. In the first year the interest cost differential is $1.5 million or $750 per flight hour (assuming 2,000 revenue-producing flight hours per year), and over the 14-year period the differential cost is $10.5 million or an average $375 per flight hour. While the magnitudes are less, the cost differential impact on a commuter airline purchasing a $1.5–2 million aircraft is jut as severe.

Even in those cases in which the US. manufacturer is able to win a competition over the subsidized foreign financing by offering some compensating concession, there remains an inherent, latent trade distortion, in that the foreign subsidy offer has induced a transfer of wealth from the U.S. manufacturer to the purchasing airline, leaving the manufacturer with fewer resources available for the research, development, and production of the next generation aircraft, whereas the foreign competition often does not rely on profit from present models to fund development of future models, but rather draws on new government funding support for new models.

Sales outside the United States.—For export sales, U.S. manufacturers and/or their foreign customers can apply to the Export-Import Bank of the United States (Eximbank) for financing assistance, whether in the form of direct credits, loan guarantees, or discount loans.

To the extent that Eximbank provides assistance, export financing for commercial aircraft generally involves direct credits and/or loan guarantees, whereas business jets and general aviation aircraft would utilize the discount loan program. But all of these programs have a cost, and the general policy of the Administration is to reduce, where possible, Government involvement in the economy.

To a very considerable extent, financing for aircraft exports can be funded by the private market—in somes cases, because of the long-term foreign risk involved, the assistance of an Eximbank loan guarantee will be necessary. The general position of the U.S. aircraft industry is that export financing should be at market rates of interest with market-determined repayment periods, so the Eximbank direct credit funding and interest-rate subsidy could be eliminated. To achieve this result without loss of competitive position, of course, requires that our trading partners also eschew subsidized financing. Unfortunately those involved with the export financing of the Airbus have not yet agreed to such an approach. To the extent that Airbus, commuter, and business jet aircraft are sold with subsidized foreign export credit financing, our manufacturers are at a competitive disadvantage, unless they receive comparable support from Eximbank or are able to utilize the long-term capital markets of the United States to compensate for the foreign subsidization, which is why some in the U.S. industry have advanced the concept of equipment trust certificate financing in which the party providing funding is accorded an equity share in the underlying aircraft asset.

Commercial Aircraft.—Another problem confronting the commercial aircraft manufacturers is that of raising sufficient fund to finance the expected production over the next decade. The total market for commercial aircraft over the next ten years is estimated at $120 billion—more than twice the value of sales in the decade of the 1970's. Funding must be found, whether from government or from private sources, to finance this expected volume of sales—and that task is clearly too large for any one source, even governments. The answer will of necessity be a wide variety of funding sources, to include an increased resort to long-term funding, as the traditional short-term funding sources will likely not have the resources necessary to meet the total requirements.

Question 3. What steps could the U.S. Government take to help our commercial aircraft industry to compete with respect to the financing arrangments?

Answer. The U.S. Government should seek to equalize the financing competition. We are presently in negotiations to establish strong disciplines on export credit subsidies, with the objective of eliminating them. Until our trading partners agree to eliminate their subsidies, some assistance from the Eximbank will be necessary to maintain financing competitiveness for U.S. aircraft. To a limited extent these negotiations have been successful already, in that there is agreement that the minimum interest rate for large commercial jet transports will be 12 percent. Agreement on this minimum interest rate, while not eliminating subsidization, has substantially reduced the level of subsidies. Unfortunately, at European insistence, the maximum repayment period is unrealistically short—ten years, or in the case of leases, twelve years. We are attempting to negotiate an option providing for market-determined rates of interest and repayment periods.

Two GATT agreements signed in 1979, the Agreement on Subsidies and Countervailing Measures and the Agreement on Trade and Civil Aircraft, state clearly that assistance governments provide to foster exports should not adversely affect the trade interests of others. The Agreement on Subsidies and Countervailing Measures, among whose signatories are all of the major aircraft manufacturing companies in the free world, includes in its listing of prohibited trade distortive export subsidies the following:

The grant by government (or special institutions controlled by and/or acting under the authority of governments) of export credits at rates below those which they actually have to pay for the funds so employed (or would have to pay if they borrowed on international capital markets in order to obtain funds of the same maturity and denominated in the same currency as the export credit), or the payment by them of all or part of the costs incurred by exporters or financial institutions in obtaining credits, insofar as they are used to secure a material advantage in the field of export credit terms.

Provided, however, that if a signatory is a party to an international undertaking on official exports credits to which at least 12 original signatories to the Agreement are parties as of 1 January 1979 (or a successor undertaking which has been adopted by those original signatories), or if in practice a signatory applies the interest rate provisions of the relevant undertaking, an export credit practice which is in conformity with those provisions shall not be considered an export subsidy prohibited by this Agreement.

This second paragraph has unfortunately led some to believe that it provides protection against countervailing duties with respect to subsidized export credits on aircraft. There are no international undertakings which provide a guide for acceptable or reasonable rates of interest for export credits for sales of civil aircraft into the United States or an exception from the above internationally accepted definition of subsidized export credit financing.

Hence, with respect to the subsidization of export credits on aircraft sales in the United States, U.S. countervailing duty law provides for the application of a remedy to an unfair trade practice, such as subsidization of export credits, if it is shown that there is indeed a subsidy and that there is injury or the threat of injury to U.S. industry as a consequence of this subsidy. Subsidization of official export financing—whether subsidization of interest rates or other government-supported financing concessions—offers an artificial competitive advantage to foreign manufacturers selling in the United States, which could cause injury to U.S. firms. Consequently, we have indicated to our trading partners our specific objection to the subsidization of financing by foreign governmental institutions in support of sales of civil aircraft (and other goods) into the United States and of our desire to negotiate an end to all subsidization of exports credits.

Question 4. What recommendations can you make to the U.S. transport aircraft industry witrh respect to the overseas market?

Answer. Our companies are much more familiar with the competitive situation in overseas markets than are those of us in Government. However, I might note that our companies need to do more in terms of devloping long-term private instruments for financing aircraft sales, which in a number of cases will likely require Eximbank financial guarantees. The industry is actualy aware of this need, and is presently engaged in developing additional sources of funds to assist in financing export sales.

Question 5. What is your view of why the U.S. industry has essentially ignored the commuter aircraft market?

Answer. When the trunk airlines and the major aircraft manufacturers moved into the jet era and larger transports, there was no incentive to develop new aircraft, whether propeller or jet powered, for the second and third tier airlines. Part 298 of the Economic Regulations of the U.S. Civil Aeronautics Board limited noncertificated carriers (the air taxi and commuter operators) to aircraft with a seating capacity of not more than 30. The so-called local service carriers in the United States had a large supply of new and used aircraft such as Douglas DC-3's and DC-6's; Martin 202's and 404's; Convair 240's, 340's, and 440's (many of which were converted to a turbo-prop version designated the 580); and Fokker-Fairchild F-27's and FH-227's to satisfy their requirements until they in time transitioned to jets.

Thus there was not in the 1970's a substantial market for a new-design commuter-type aircraft with 30-60 seats. Indeed there was little demad for new 20-seat aircraft. Here again economics was a factor. The U.S. Federal Aviation Administration does not require a flight attendant in the passenger cabin of an aircraft with 19 or fewer seats. But with 20 seats an attendant is required, and then economics requires enough additional seats to pay for having the attendant on board. (An attendant requires not only a salary, but also a seat, and adds to the weight.)

At the same time, technological developments, traffic growth, and economic imperatives combined to lead to larger and larger jet transports. The concern of airlines and aircraft manufacturers with investment cost per seat and operating cost per seat-mile has also led to increases in the seating capacity of each series of jet transports.

By 1978 only one civil passenger transport in the 15-95 seat range was in production in the United States, Swearingen's Metro II, an 18-22 seat twin-engine turboprop—and if a derivation of the Merlin IV corporate aircraft. And none were planned. The investment cost in a new program was a barrier that had to be overcome. The FAA was revising its airworthiness certification requirements for commuter-type aircraft; knowledge of these was a prerequisite for launching a new program, or even resurrecting an old one.

Foreign manufacturers were in a somewhat different situation. In most cases, their production programs are supported by their governments. Government funds are available for launching projects, and for continuing programs with low production rates. Public investment in aircraft programs is deemed to be a reasonable means of earning foreign exchange, assisting in industrial development, or providing for particular transport requirements (such as in remote regions of Australia or Canada with unpaved landing strips, or where runways or approaches are short). Thus, the hurdles to launching a program are lower, and the economic requirements as to production efficiency are less stringent.

The Airline Deregulation Act of 1978, the promulgation of the new FAA certification regulations for commuter aircraft, and the demand for small community air services have had a revolutionary impact on the commuter aircraft industry. While these developments are all domestic, they have important consequences for the world's commuter aircraft manufacturers.

The limitation of air taxis and commuters to aircraft of not more than 30 seats has been changed to aircraft of not more than 60 seats. And it is now easier to establish an airline, using any size aircraft. Thus for the first time in over a decade there are potential customers in the United States for commercial passenger aircraft in the 30-55 seat range. Trunk and local service carriers have greater freedom in eliminating services of their now relatively large jets at points where such services are not economically viable, and these low frequency, high capacity services can be replaced by the higher frequency, lower capacity services characteristic of a commuter-type operator. Commuter airlines have started to serve these markets, and thus we find a significantly larger market requirement for commuter aircraft than in the past 15-20 years.

Question 6. What do you believe is required of the U.S.Government to improve our national competitiveness in the commuter aircraft and general aviation markets?

Answer. The competitiveness balance is determined by a number of key factors—aronautical technology, manufacturing technology, willingness to take marketing risks, which is influenced by estimates of the customer base and the ability to raise investment funds, and finally, the timing of introduction/availability of products.

The U.S. Government historically has had a contributing role in respect to several of these factors. My understanding is that the United States is fully competitive in aeronautical technology and is in a leading position in terms of manufacturing technology. However, our relative position in respect to aeronautical technology can be eroded, if we do not maintain strong, comprehensive aeronautical R&D efforts.

Many foreign manufactuers do not face the same market economic disciplines, as do U.S. firms with respect to civil aircraft production, as their governments are willing to bear much, if not all, of the economic risk in launching programs, and to sustain what in the United States would be uneconomic production rates. For example: The Australian Nomad twin-turboprop light utility aircraft was certificated in August 1972 and will go out of production in 1984 after a total production of 170 units (fewer than 15 per year).

The Israeli Arava light STOL transport was certificated in April 1972; fewer than 100 have been sold; and it is still in production.

The Spanish CASA C-212 Aviocar twin-turboprop light utility STOL transport first flew in March 1971; as of January 1, 1980, some 186 had been sold.

The United Kingdom's prototype 30-seat Shorts 330 first flew on August 22, 1974, with certification coming on February 18, 1976; four years later deliveries stood at 30, with an additional 30 aircraft being on firm order. (This aircraft was in production and available to U.S. commuter airlines as that industry expanded rapidly with passage of the Airline Deregulation Act of 1978).

The United States Government should not emulate the practice of maintaining uneconomic production rates. But it would be meaningful to have a study of our commuter aircraft market, especially as a consequence of the Airline Deregulation Act of 1978, in order to establish the determining factors regarding production of aircraft. A manufacturer undertaking to introduce a new commuter aircraft would probably have to put a $400-500 million investment at risk and allow for a four-year development period. Thus, essentially he would be betting $400-500 million that four years hence the commuter airline industry will have sufficient economic strength and market stability so as to be in a position to purchase a substantial number of his aircraft. Of course, he has also the risk of delays in meeting established airworthiness and environmental requirements, and the challenge of competitive models, some of which may be offered on the market with the benefit of foreign government subsidized financing and some of which are in production only because of foreign government support of their manufacturer.

In my view, the United States Government—

Should seek to assure a strong, effective commuter airline industry, which would generate a reliable market base. (A program such as the FAA Equipment Loan Guarantee Program is a positive influence, as it enhances confidence that purchasing airlines can obtain the necessary financing at a cost accorded a prime risk borrower.)

Should minimize the uncertainty and costs associated with Government regulatory policy while providing essential safety and environmental criteria. (Fluctuating or uncertain regulatory policies increase the risk of economic success of a production program, and so tend to delay commitment of investment funds.)

Should seek to assure that financing for sales of foreign aircraft does not benefit from foreign government subsidies, as U.S. manufactured aircraft, for which the purchase financing bears market rates of interest, would be at a competitive disadvantage in our own domestic market.

Should seek to assure, as provided for in the GATT Agreement on Trade in Civil Aircraft, that the pricing of foreign civil aircraft is based on a reasonable expectation of recoupment of all costs, including development costs, production costs, and financing costs, whether or not aided by government funding.

Have a policy of not procuring civil-derived aircraft, whether for civil or military purposes, from foreign suppliers without first assuring, inter alia, that the pricing is based on a reasonable expectation of recoupment of all costs, including development costs, production costs, and financing costs, whether or not aided by government funding. In particular, U.S. Government funding of an aircraft development and production program is not providing a pricing advantage for a foreign aircraft over a competitive model from a private U.S. manufacturer.

Question 7. Would you say the problems facing competitiveness in the commercial aircraft market and the rotocraft market are the same?

Answer. While the competitive problems are not identical, they are essentially the same. U.S. helicopter manufacturers are facing increasingly strong foreign competition, competition which in some instances is heavily supported by foreign governments, in terms of both political pressures and financing arrangements.

Question 8. Do you think our current pollicy decisions with respect to the aerospace industry are based on our pre-eminent position of the past, rather than on a realistic outlook for the future?

Answer. Regretfully, I must agree with the thrust of the question. In asessing current policy options, there is a tendency to consider the present status of the industry in terms of the composition of the existing world aircraft fleet, which is a reflection of past, not present status. In mathematical terms, there is a tendency to assess current status as where we are now, and to ignore the first derivative of the competitive position curve, which is where we are headed, and also, the second derivative (the aeronautical R&D and program development component) which determines our future rate of change of competitive ascendency or descendancy.

The composition of the existing world aircraft fleet reflects, not today's competitiveness, but the competitive situation in aircraft technology, product development, engineering and manufacturing capability of 10-20 years ago when the Boeing 727, 737, and 747, the Douglas DC-9 and DC-10, and the Lockheed L-1011 were introduced. The composition of the wide-bodied fleet ten years hence depends upon today's orders, and the composition in 15-20 years' time depends upon today's competitive ability to develop and launch aircraft and engines.

Question 9. In your statement you say that in 1981 the dollar value of civil aircraft and parts totaled $19.4 billion and the comparable military items were $20.7 billion. Doesn't this imply that our civil and military aircraft activities are as important to out economic national security as to out defense national security?

Answer. In a word, yes. Aerospace is not only a major industry, with employment exceeding 1,200,000 Americans, but it is also a high-technology growth industry, and an industry that generates a demand for sophisticated machine tools, electronics, and materials, which in turn stimulates more economic growth. The industry has a strong record of international competitiveness, R&D investment, and productivity gains—all important elements of economic national security.

The civil aircraft activities are also important contributors to defense national security, as they provide a medium for technological advancement which can be transferred to military items—obvious examples are the KC-10 and the business jets that were being considered by the Air Force as companion trainers for B-52 crews. The civil production base also provides an emergency reserve of trained manpower and modern facilities that can if and as the need arises, be shifted to military equipment production, a defense national security reserve that is maintained in operating condition at no cost to the Nation.

Senator CANNON [presiding]. All right. Thank you very much.

Next is Mr. Wolfgang Demisch, Morgan Stanley & Co. Dr. Demish.

STATEMENT OF WOLFGANG H. DEMISCH, VICE PRESIDENT, MORGAN STANLEY & CO., INC.

Mr. DEMISCH. Senator Cannon, Mr. Chairman, ladies and gentlemen, thank you for your invitation to address this subcommittee with respect to the implications of the fiscal year 1983 NASA budget for the U.S. aerospace industry. My perspective on this issue is financial. I am a vice president with the investment banking firm of Morgan Stanley, and I specialize in aerospace.

Before we examine the issue, however, a brief background on the industry. Aerospace is an American success story. In the United States, it is a $60 billion business, about one-third commercial. It employs 1.25 million Americans. It provides a $35 billion payroll. It generated about $3 billion in profit in 1981.

It is by far our largest source of manufactured goods export, with $18 billion in shipments in 1981, of which only $4 billion were military. By dollar value we have built 90 percent of the world's air fleet and remain preeminent, despite growing overseas competition.

Our airliners are our best ambassadors. They offer superior quality, safety, comfort, and reliability at economical costs. They speak well of America both to operator and user.

This superior U.S. performance is no accident. It is in good part the consequence of an outstandingly effective partnership between Government and industry, a partnership begun in 1915 with the establishment by Congress of the National Advisory Committee for Aeronautics and maintained when the NACA was assimilated into NASA in 1958.

The aim of this partnership was and is: "to preserve the role of the United States as a leader in aeronautical science and technology and the applications thereof." Toward that end, over the past decade NASA has spent $4 billion on aeronautics research. Industry has committed four times as much. The country benefited from a $65 billion aerospace trade surplus over the same period.

Clearly the partnership works, and works well. It does so by efficiently linking NASA's technical talent, the country's best, to the industry's financial marketing and manufacturing skills. It separates the two major uncertainties in aerospace development—will it work and will it sell—and it addresses each in the most efficient manner.

NASA is best positioned to address the technical uncertainties inherent in aerospace, the will it work part. Its infrastructure is the best in the business and its personnel have the best overview of the technical options available.

NASA can interact freely with both industry and the academic world. It receives problems and data from the military and the commercial arenas alike and can cross-fertilize between the disciplines in ways impossible to industry, where airframes, propulsion and subsystems are split among several companies and those companies are mutually competitive.

The industry is not positioned to share its insights or its problems and, in fact, antitrust law would prohibit any such sharing.

Within that context, the technical pathfinding work NASA performs is only the first step in the creation of a finished product. An enormous task remains after the technology involved has been demonstrated.

The next step, designing and producing a product which the market can use and which the market can afford to buy, is a lot more expensive than NASA's technology work and it is best performed by private industry which aims to make a profit rather than by the taxpayer.

Managements become a lot more sensitive toward the real needs of the marketplace when their own funds are at risk rather than when the Government pays the bills and the market is, of course, the final arbiter of the success of the investment.

In the best of circumstances, a decision to build a new aerospace system is very, very high risk. The capital commitment necessary is comparable to the net worth of the builder, and the payoff is typically a decade away.

The current interest rate environment, where U.S. Government debt pays 15 percent a year, is a further hurdle. Projected future earnings streams discounted back to a present value provides an unacceptably low return in almost all instances at these current rates. So you have to bet that inflation will go down to invest any money at all. Together, these factors make aerospace decisionmaking an art which requires high willingness—in fact, some might say a fondness—for risk.

The two or three largest companies in the business have a capitalization of about $3 billion each. The others are smaller. Against that, the launch costs of a new airliner is about $10,000 a pound, about $2 billion in the case of the 767, and about $20,000—maybe $30,000—a pound of thrust for a new jet engine, over $1 billion for Pratt & Whitney's new 2037. Manufacturing facilities and subsystems work, of course, costs extra.

These sums, plus the comparable work-in-process investment, must be committed over the first 5 years of a program's life, and are never recovered if the project flops. The process may be fairly described as you bet your company.

Sometimes, of course, the bet does not come off. In that case, the company faces at best a long period of convalescence, while management and stockholders lick their wounds. At worst, you have bankruptcy. Lockheed, rescued by a Government loan guarantee, is the best known U.S. example, but there have been and there continue to be examples both here an abroad to underline the reality of the market risk.

Given this high inherent market uncertainty, management would be suicidal to accept basic technical unknowns as well. Rolls Royce provided a striking example a decade ago. The firm, for its new RB–211 engine, selected HyFil, a light but strong carbon fiber composite material, for the fan blades of the engine. The fabrication technology of that stuff was well in hand, but the systems technology work had not been done.

In any event, the material was too brittle, was unable to absorb the impact of hailstones or birds, which represent a sometime hazard to airplane engines. The cost in time and money of the required redesign bankrupted Rolls-Royce and, of course, helped bring Lockheed to its knees.

In short, the aerospace market risk is bad enough even if it works. Technical concerns in addition are extremely chilling, and this is one of the reasons, perhaps, why United Technologies, a leading jet engine builder, currently is selling at less than five times trailing 12 months earnings, which is a 30-percent discount to the average run-of-the-mill industrial stock in this country.

United Technologies has guaranteed that its new 2037 engine will be 8 percent more fuel efficient than its competitors' derivative designs. Investors perceive this as an overhanging liability, assume the worst—namely that they will not be able to do it—and accordingly pay less than the shares deserve, at least in my opinion.

This background, I think, may help to illustrate why in my opinion it would be unwise to starve the NASA system technology effort, as is proposed in the 1983 budget. For a savings which in my judgment is trivial we risk vandalizing an efficient and productive mechanism for bringing the best skills of the Nation to bear on the most pressing problems of one of our most successful industries.

We need some such sort of interface ongoing and working if the results from the slightly more generously funded technology base programs are ever to leave the ivory tower of the research environment and contribute in the real world.

Now I note that once destroyed this kind of interface is not easily restored. The essential people which make it work well today, because they have had long experience and they know everybody within the aeronautics community, will have been dispersed. Until you reacquire the institutional memory that these people represent—and that is a decades-long job—the replacement effort is going to be less effective.

In addition, the subcommittee has got to be aware that there is no prospect of the industry being mobilized in time to save this portion of NASA's operations. Military suppliers today face a cutback by about one-third in their cashflow because of the proposed elimination of completed contract accounting as of January 1, 1983, and they are scrambling merely to meet their existing obligations.

Civilian producers, meanwhile, are watching an unprecedented unravelling of formerly firm orders as airlines whose financial resources were adequate in the more sheltered environment operated by the CAB find themselves overextended in the more demanding deregulated market. Survival correspondingly dominates this industry's priorities.

It is true that eventually you could work out, I think, an arrangement to fund this work by industry. NASA's work is relatively cheap. The industry does generate enough profit to sustain the necessary to do this systems technology work. However, there is currently no tested legal mechanism to initiate that kind of a jointly funded program and maintaining it would be difficult.

First of all, there would be a loss of autonomy by that part of NASA that has to respond to industry pulling the strings and there would be correspondingly less access to those workers on the part of both the military and the academic community.

Second, once you have many masters, how do you decide which one to serve? There are a multitude of problems to be solved. Setting priorities would certainly lead to disagreements among the sponsors, probably enough to break up the effort.

I do not think a privately sponsored institution would be anywhere near as vigorous and effective as NASA. The best that you could hope for is an emulation, I think, of the relatively anemic Electric Power Research Institute, and that is being optimistic.

Against this prospect of reduced effectiveness I think it is appropriate for the subcommittee to consider the impact on the competitive position of the U.S. industry in the world. I think the evidence is clear that we are losing ground and the erosion reflects a decline in our technology effort over the past decade or more.

The loss of position is easily documented. Most strikingly, last year Airbus, which is lavishly supported in Europe, sold more wide body aircraft, 64, than all U.S. manufacturers put together, 43. This is a far cry from our historic 90-percent share. Furthermore, in the fastest growing portions of the world aircraft market, the Pacific Rim and the Mideast, Airbus has outsold the United States by about 3 to 1 over the past 3 years.

They offer technically competitive product at an attractive and sometimes unbeatable price, and we have nothing in our technical bag of tricks to offset Airbus and their financial edge in the marketplace. We exported $10 billion worth of commercial aircraft last year. That is 200,000 jobs. That market is at risk.

Closer to home, our aerospace trade balance, although still strongly positive, in fact is eroding. From 1971 to 1982, our aerospace exports went up a bit more than four times, to $18 billion from $4.2 billion. Our imports, by contrast, rose more than 11 times and at $4.2 billion now are almost 25 percent of our exports. That is the highest foreign penetration since before World War II.

The surge in foreign penetration has been greatest in general aviation, which is the small business aircraft and commuter airliner segment of the industry. That market has been by far the fastest growing segment in aerospace. The 30-year average annual dollar growth has been 16 percent. But it is small. It is only about $3 billion and consequently it has long been a neglected segment and has gotten very little of NASA's money—not that NASA has a lot—and it has been correspondingly stagnant technically.

That market has become ripe for aggressive foreign competition and as a result in 1981 we had a trade deficit in general aviation for the first time ever. Unless we maintain our technical leadership by supporting our centers of innovation I expect this to be a harbinger of things to come.

Thank you very much.

Senator CANNON. I am just wondering, in light of the thrust of your last comments, as to whether we are losing leadership in technology. Is it not more of a situation where financial arrangements made by some of our foreign competitors have been much more favorable than our own contractors?

Mr. DEMISCH. Absolutely correct. What I am saying is the foreign competition receives a support or subsidy. In the case of Airbus the data is not all that clear, but there are periodic German Government documents that suggest that the annual subsidy is between a quarter and a half billion dollars, and, running the numbers, this is cheaper than having the people on welfare, so it is a good business for the governments involved.

Sure they are highly competitive in financing and more than highly competitive, even unbeatable, but the point is we do not have anything to offset it. If all we have is a me too product, no technical edge like we used to have, then basically, if it gets down to my government subsidy against your government subsidy, we are behind the eight ball.

We have the brains in this country to do better than that, but what we are doing currently is starving the technical support. At this rate, 5 years from now, industry is going to be coming to Uncle Sam screaming for a handout. This is not bright.

Senator CANNON. Your example of the disastrous consequences of Rolls-Royce's premature introduction of a new material for fan blades without technology validation, such as NASA programs provide, is certainly confirmation of the need for that kind of a program, in NASA, obviously.

Mr. DEMISCH. Well, I would certainly think so. You need a transmission belt to get the knowhow from the lab into the field and you need to test it so that it will more or less work in the field. The systems technology work is what does that and it is cheap.

Senator CANNON. Perhaps I should ask you the same question that I asked Dr. Piper, which he did not respond to and said it was out of his line of business, and that is, is it not a fact that the elimination of systems technology programs to achieve a $65 million budget reduction would appear to be penny-wise and pound-foolish?

Mr. DEMISCH. I could not agree more. I think it is shooting yourself in the foot,

Senator CANNON. Now I want you to know that is not what I did.

Thank you very much for your very fine testimony.

[The statement follows:]

STATEMENT OF WOLFGANG H. DEMISCH, VICE PRESIDENT, MORGAN STANLEY & CO., INC.

Mr. Chairman, Senators, ladies and gentlemen. Thank you for your invitation to address this Subcommittee with respect to the implications of the Fiscal 1983 NASA budget for the U.S. aerospace industry. My perspective on this issue is financial. I am a Vice President with the investment banking firm of Morgan Stanley, and I specialize in aerospace.

Before we examine this issue, however, a brief background on the industry. Aerospace is an American success story. In the United States, it is a $60 billion business, about one-third commercial. It employs 1.25 million Americans, provides a $35 billion payroll, and generated about $3 billion in profit in 1981. It is by far our largest source of manufactured goods export, with $18 billion in shipments in 1981, of which only $4 billion were military. We have built 90 percent of the world's air fleet, by dollar value, and remain preeminent, despite growing overseas competition. Our airliners are our best ambassadors, offering superior quality, safety, comfort and reliability, at economical costs. They speak well of America, to operator and user alike.

This superior U.S. performance is no accident. It is in good part the consequence of an outstandingly effective partnership between government and industry, a partnership begun in 1915, with the establishment by Congress of the National Advisory Committee for Aeronautics (NACA) and maintained when the NACA was assimilated into NASA in 1958.

The aim of this partnership was and is ". . . to preserve the role of the United States as a leader in aeronautical science and technology and the applications there of . . ." Toward that end, over the past decade, NASA has spent $4 billion on aeronautics, while industry committed four times as much. The country benefited from a $65 billion aerospace trade surplus over the same period.

Clearly this partnership works, and works well. It does so by efficiently linking NASA's technical talent, the country's best, to the industry's financial, marketing, and manufacturing skills. This separates the two major uncertainties in aerospace development, i.e., will it work and will it sell, and addresses each in the most efficient manner.

NASA is best positioned to address the technical uncertainties inherent in aerospace, the "will it work" part. Its infrastructure is the best in the business, and its personnel have the best overview of the technical options available to solve problems most efficiently. NASA can interact freely with both industry and the academic world. It receives problems and data both from the military and the commercial arenas, and can cross fertilize between the disciplines in ways impossible to industry, where airframes, propulsion, and subsystems are generally split among several companies, which are mutually competitive, rather than positioned to share their insights or problems. Indeed, antitrust restrictions would forbid such sharing.

The technical pathfinding work NASA performs is, however, only the first step in the creation of a finished product. An enormous task remains even after the technology involved has been demonstrated. This next step, designing and producing a product which the market can use is much more expensive than NASA's technology work, and is best performed by private firms, seeking to obtain a profit rather than the taxpayer. When investing their own funds, managements become much more sensitive toward the real needs of the marketplace than when the government pays the bill, and the market is the final arbiter of the success of the investment, at least in the commercial arena.

Even in the best of circumstances, a decision to build a new aerospace system is extremely high risk. The up front capital requirement is comparable to the net worth of the builder, and the payoff is typically a decade or more away. The current interest rate environment, where U.S. obligations pay 15 percent per year, raises a further hurdle. The projected future earnings streams discount back to unacceptably low present values in almost all instances at these rates. Together, these factors make aerospace decision making an art requiring very great willingness to live with risk. The two or three largest companies in the industry enjoy capitalizations of $3 billion, but the others are much smaller. Against this, the launch cost of a new airliner is $10,000 per pound of airframe weight, perhaps $2 billion in the case of the Boeing 767 and about $20,000 per pound of thrust for the engines, over $1 billion for the new Pratt & Whitney 2037.

Manufacturing facilities and subsystems cost extra. These sums, plus a comparable work-in-process investment, must be committed over the first five years of a program's life, and are never recovered if the project flops. The process may be fairly described as "you bet your company." Sometimes the bet does not come off. In such cases, the company faces at best a long period of convalescence, while management and stockholders lick their wounds, at worst bankruptcy. Lockheed, rescued by the Government loan guarantee, is the best known U.S. case, but there have been and continue to be additional examples both here and abroad to underline the reality of the market risk.

Given this high inherent market uncertainty, management would be suicidal to accept technical unknowns as well. Rolls-Royce provided a striking example a decade ago. The firm selected HyFil, a light, but strong carbon fiber composite material, for the fan blades on its new RB-211 engine. The fabrication technology was well in hand, but the systems technology work remained undone. In the event, the material proved too brittle, unable to absorb the impact of hailstones or birds, which represent a sometime hazard to jet engines. The cost in time and money of the required redesign bankrupted the enterprise, and also helped bring Lockheed to its knees.

In short, the aerospace market risk is bad enough even if it works. Technical concerns in addition are very chilling. This is at least one reason why United Technologies, our leading jet engine builder, currently sells for less than five times trailing 12-months earnings, a thirty percent discount to the average industrial. UTX has guaranteed that its new 2037 engine will be 8 percent more fuel efficient than its competitors derivative designs. Investors perceive this as an overhanging liability, assume the worst, and accordingly pay less than the shares deserve in my opinion.

This background may help illustrate why it would be unwise, in my opinion, to starve the NASA system technology effort, as is proposed in the fiscal 1983 budget. For a truly trivial savings, we risk vandalizing an efficient and productive mechanism for bringing the best skills of the nation to bear on the most pressing problems of one of our most successful industries. Some such interface is essential if the results from the slightly more generously funded technology base programs are ever to leave the research environment and enter the real world.

And yet, once destroyed, it will not be easily restored. The essential people which make it work well today, thanks to their long experience within the aeronautics community, will have been dispersed. Until the institutional memory they represent will have been reacquired, a decades-long endeavor, the replacement will be less effective. The subcommittee must also be clearly aware that there is no prospect of industry being mobilized in time to save this aspect of the NASA operation. The military suppliers today face a one-third cutback in their cash flow because of the proposed elimination of completed contract accounting after 1982, and are scrambling merely to meet their existing obligations. Civilian producers meanwhile are watching the unprecedented unravelling of formerly firm order, as airlines whose financial resources were adequate in the sheltered environment operated by the CAB find themselves overextended in the more demanding deregulated market. Survival correspondingly dominates this industry's priorities at present.

It is true that eventually an arrangement could perhaps be worked out, because NASA's work is relatively cheap, and the industry does generate enough profit to sustain the tithe needed to sustain this effort. However, no currently tested legal mechanism exists to initiate such a jointly funded program, and maintaining it would be difficult. There would be a substantial loss of autonomy by that part of NASA, with correspondingly reduced access granted to its workers by the military and academia. Moreover, deciding which of a multitude of problems to solve would be a difficult problem, certain to lead to disagreements among the sponsors, probably enough to break up the effort.

In short, I doubt a privately sponsored institution could play anywhere near as vigorous and effective a role. An emulation of the relatively anemic Electric Power Research Institute is probably the best that could be hoped for.

Against this prospect of reduced effectiveness, it is appropriate for the subcommittee to consider the impact on the competitive position of the U.S. industry in the world. I believe the evidence suggests that we are already losing ground, and that the erosion reflects a decline in our technology applications effort over the past decade. The loss of position is easily documented. Most strikingly last year, Airbus Industrie, Europe's lavishly supported civil transport consortium, sold more wide bodied aircraft (64) than all U.S. suppliers put together (43). This is a far cry from our historic 90 percent share. Furthermore, Airbus has outsold the United States in the fastest growing air transport markets of the world, the Pacific Rim and the Mideast, by about 3 to 1 in the last 3 years. Airbus offers a technically competitive aircraft at an attractive, sometimes an unbeatable price. We had nothing ready in our technical bag of tricks to offset Airbus; financing edge in the marketplace. Last year, we exported $10 billion in commercial aircraft, about 200,000 jobs equivalent. That market is increasingly at risk.

Closer to home, our aerospace trade balance, although still strongly positive, is in fact steadily eroding. From 1971 to 1982, our aerospace exports have risen 4.3 times, rising to $18.1 billion from $4.2 billion. Our imports, by contrast, have risen 11.4 times, and at $4.3 billion, are almost 25 percent of our exports, the highest penetration since before World War II, up from 9 percent in 1971.

In this context, it is noteworthy that the surge in foreign penetration has been greatest in general aviation, the small business and commuter airliner industry. Even though this market has been by far the fastest growth sector in aerospace, with a thirty year average annual gain of 16.5 percent, it is very small, at $3 billion, and consequently has long been a neglected segment of the industry. Having received essentially none of NASA's scarce funds, and correspondingly, stagnant technically, this market has become ripe for aggressive foreign competition. As a result, in 1981, we had a trade deficit in general aviation for the first time ever. Unless we maintain our technical leadership by supporting our centers of innovation, I expect it to be a harbinger of things to come.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. How does the financing of commercial aircraft supplied by U.S. manufacturers compare to the financing of commercial aircraft supplied by foreign manufacturers? Please provide detailed comparisions. For example, what is the "sometimes Unbeatable price" you alluded to in your presentation?

Answer. Financing is the critical variable in the airline's purchase decision. There is very wide latitude to substitute equipment, even between narrow and wide bodies, if the price is right. For example, Eastern Airlines was induced to buy A-300 Airbuses, a new type, and wide bodied, in lieu of an additonal number of 727-200s, by a creative package including: a free "fly at out risk" six month lease, a concessionary $22 million purchase price, (about twice the price of a 727, rather than the more typical three times) plus an innovative "pay only for the capacity you need" feature providing a partial refund to Eastern for the cost of the A-300s excess capacity vis-a-vis the smaller A-310s, then just entering development, that fitted Eastern's needs better. Finally, the financing was handled through European banks at a discount from prevailing rates.

Against this panopy of special offers, backed by supplementary government-to-government incentives in the case of many international sales, U.S. producers can provide, sometimes, below market rate financing using the Export Import bank, now however severely curtailed, and a range of services at reduced rate, especially training, as well as tradein offers of older, generally U.S. built equipment. Collectively, these concessions are limited by the need of the U.S. producers to retain commercial viability themselves.

It should be noted that Soviet aircraft are typically sold at 50 percent discount prices, and often at totally arbitrary interest rates, as low as 2 percent per year. However, their poor operating characteristics, particularly the inefficiency and low reliability of their engines, have made these types almost unsalable. Airbus circumvented the technology gap by using U.S. engines and electronics at least initially. Unfortunately, the U.S. used neither technology export restraints nor enjoyed structural technological advantages to offset Airbus's marketing efforts.

Question 2. What steps do you suggest on the part of the U.S. government to improve this financing situation with respect to our commercial aircraft industry?

Answer. It is clear that the U.S.'s interest would be best served by an elimination of the various government financing subsidies in aircraft. An international equipment trust certificate, which would be honored throughout the ICOA states to ensure the creditor's legal rights might offer an avenue to standardize world aircraft finance.

If such a vehicle cannot be set up, in my opinion only the threat of aggressive competition can restore some degree of stability to the current free for all, where the U.S. is typically the loser. However, I doubt the Congress would be ready to expand the Ex Im bank's authority to the $25-$30 billion necessary to make such a threat credible. An effective alternative might be to threaten to reduce access to the U.S. components critical to Airbus. Of course, this runs the risk of accelerating Europe's drive for self-sufficiency in aeronautics, but the disruption would be a severe blow to Airbus.

Finally, we should be under no illusion that the sales will ever be entirely free of non-commercial pressures. Thus far, rumored Airbus purchase incentives have included access to French arms in South Africa, EEC aid in India and Korea and weapons purchases for Brazil. Airbus is a creation of the major European governments, and hence will continue to enjoy the benefits of being an instrument of these entities policy.

Question 3. Would you please elaborate on your answers pertaining to the financing of the Airbus Industries' aircraft. What percentage of each Airbus A300 and A310 selling price reflects a government subsidy? Please include the estimated total of all governments.

How do these compare to U.S. commercial aircraft sales prices?

Answer. Airbus' prices are normally set by its U.S. competitors. The price is what is needed to be very competitive, generally a little better. When there is no competition the price goes up steeply, to $75 million in a recent Singapore Airlines order.

The details of Airbus' finances are murky, and hence the following overall estimates have only the status of best guesses, based largely on German data, extrapolated to the other participants. An Airbus today sells for $50 million. The German credit to date, excluding marketing support, is 2.43 marks, or about 15M marks on the 160 aircraft built to date. Marketing support is about 6M mark per aircraft, so total help is 21M marks per aircraft for Germans, which handles 37.5 percent of the Airbus. This suggests a total subsidy of about $25 million per aircraft, including unrecovered launch costs, indicating the Airbus is sold at about two-thirds of full cost.

These numbers may be challenged on grounds that government's credits of 2.4 billion marks should be amortized over a much larger number of aircraft. I would point out, however, that the Lockheed TriStar was launched about the same time as the A-300, and has generated $2.5 billion in net losses for Lockheed on shipments of 220 aircraft, a rather better number than Airbus'. Lockheed was an established, experienced builder of large aircraft, including the much larger C-5, unlike the Airbus consortium, which had never worked together before, and started from scratch building an aircraft two times larger than any of the participants had ever built. On this basis, my estimate of Airbus' true costs are reasonable, and even conservative. They are also supported by the enormous breakeven numbers being currently quoted, some 1200 aircraft of the A-300/310 family, which would carry the program well into the next century at rates, before the principal, much less any interest, on the government's advances were repaid.

Question 4. In your answer to one of the Committee's questions you stated that the German government pays a subsidy to the Airbus program in lieu of welfare payments to the workers if they were unemployed. What would the estimated equivalent welfare payments be to U.S. commercial aircraft workers if certain commercial programs are terminated?

Answer. There are presently about 200,000 U.S. commercial aircraft workers, earning an estimated $5 billion in salaries, and paying perhaps 1.5 billion in federal taxes. Unemployed, and drawing welfare, they might be expected to cost, with their families $750 million, assuming $5,000 in benefits per family. Overall, then, a negative swing in federal receipts of $2-$2.5 billion could be expected from termination of the U.S. jetliner industry.

Question 5. What is your view of why the U.S. industry has essentially ignored the commuter aircraft market?

Answer. First, I reject the premise. The U.S. industry has maintained firm control of the commuter aircraft systems business. Engines, electronics, environmental systems in these aircraft are overwhelmingly U.S. built, derived from business aircraft. What has been lost in the airframe itself. This failure began before deregulation, when Beech Aircraft discovered it could make more money using its limited capacity to make business aircraft then commuter airlines. Cessna, its principal competitor, was fully loaded building its first biz jet, the very successful Citation, and Piper, a takeover football between Chris Craft and Bangor Punta, could not afford to step in. Had Beech had the financial courage to borrow enough to expand, the problem might have been averted, but the fear of another collapse of the aircraft market as had taken place in 1969-71 made management unwilling. Deregulation then blew this market wide open, at a time when business aircraft sales were already booming. Given a choice between serving its established corporate clients and the new and untested, financially shaky communter industry. U.S. suppliers again stayed with their existing clientele. Thus the market was left wide open for foreign suppliers, who found these simple aircraft ideal as a tool to develop domestic aeronautical capabilities. The resultant profusion of government backed foreign suppliers now guarantees that no U.S. company will enter the market. Taking on one Airbus is bad enough, but a half dozen is suicide.

Question 6. What do you believe is required of the U.S. government to improve our national competitiveness in the commuter aircraft and general aviation markets?

Answer. I am not optimistic the U.S. government can do much to restore our national competitiveness in the general aviation and commuter markets. A more rigorous pursuit of overseas trade barriers, which prevent U.S. firms from selling in Brazil, for example, while Brazil sells freely in the U.S. might be helpful. Japan is a similar case, selling aggressively in the U.S. while essentially freezing their domestic market.

More broadly, however, the technology of these aircraft has stagnated for 30 years. A new Beech Bonanza flew from Honolulu to Washington in 1946. The design is still in production. Until the new composite structures being purportedly used in the Stealth program become routinely available, and until a more automated air traffic control system becomes available than the present makeshift, I do not foresee substantial progress in this sector.

Question 7. It was stated by Dr. Piper that in 1981 the dollar value of civil aircraft and parts totaled $19.4 billion and the comparable military items were $20.7 billion.

Doesn't this imply that our civil and military aircraft activities are as important to our economic national security as to our defense national security? Could you please comment on this.

Answer. Not exactly. The civil aircraft business must be compared to the overall economy, which is 20 times larger than the military budget. Hence its continuation is proportionately less crucial to the survival and prosperity of the republic. However, civil aviation does play a much more important role than our military aircraft in our balance of trade, about three times greater. Given the rapid diminuation in the number of manufacturers with which we are still able to pay our way in the world economy, I would certainly weigh the industry's economy significance much more heavily than merely its share of the overall GNP.

Senator CANNON. Next we will have a panel: Dr. Schaufele, Dr. Shank, Mr. Parmet, Mr. Withington, Mr. Donohue, Mr. Cleveland, and Mr. Neal.

We are going to insert in the record all the statements in full. We will start with Mr. Cleveland. We will follow with Mr. Parmet and then Mr. Neal, and then if others want to comment and elaborate on their statements, we will certainly take that elaboration.

All right, Mr. Cleveland.

STATEMENT OF F. A. CLEVELAND, VICE PRESIDENT, ENGINEERING, LOCKHEED CORP.

Mr. CLEVELAND. Thank you very much, Senator Cannon. I am the corporate vice president of engineering of the Lockheed Corp. My colleagues from the four major manufacturers—and I realize there are more people here than that—the subgroup that I am speaking for include T. F. Donohue of General Electric, M. E. Shank of UTC [United Technologies Corp.], R. H. Schaufele of Douglas Aircraft, and H. W. Withington of Boeing.

We, too, are appreciative of the opportunity to appear before you. We have, as you indicated, submitted our written testimony. I have submitted mine and I will attempt to summarize that even more briefly than it was written. We, of course, are here to engage in any question-and-answer period afterward, in addition to what we have submitted.

Now, in the interest of conserving your valuable time, I do not intend to harangue you with truisms with which you are as familiar as we and which were very ably mentioned by the chairman earlier this morning—the aspects of national security, of balance of trade, of splendid air transportation systems, of employment, national prestige—all of those things which are fundamentally an important part of Government responsibility and which are profoundly affected by NASA's work. We will be very happy to go into those in detail later.

Even the budgetcutters seem to agree with regard to the desirability of those fundamental characteristics of our industry and of NASA. At the same time, they are participating in a reduction in constant 1980 dollars to only 56 percent of the 1980 budget level by 1983. What we would like to do is to tackle some tougher issues with you, the first of which is fairly obvious.

Is there room for further progress in aeronautics to make R. & D. investment by anyone—NASA, industry, academe, DOD—

worthwhile and cost effective? Somehow this aeronautics community has managed to give the impression of technological success such that many believe few further gains are possible and words such as "stagnancy" in aeronautics are occasionally heard.

We are still in our technical teens, if not in our infancy. Let me illustrate with a few items.

We do not understand one of the most fundamental technical disciplines that we work with as thoroughly as we should in spite of the application of some of the best minds in the country, and that is turbulence aerodynamics, also its derivative—so important in many areas—noise.

Materials of construction of our airplanes and engines remain still to some degree a metallurgical black art, and composites have created an entire new ball game with new rules in that regard; we also now are beginning to develop the metal matrices which put us in a position of not having sufficient wisdom in two basic technologies together.

High-temperature materials are tremendously important and the scarce alloying elements which make them possible are also a special consideration for the high temperatures and the efficiency increases which we need and which we can achieve.

Internal aerodynamics improvements in our propulsion machinery, efficient propulsion for vertical takeoff-and-landing aircraft, the application of electronics devices not only in the obvious ways but for nonelectronic problem solution are most intriguing and most promising technical areas.

I have intentionally skipped over a lot, relying on implication to cover man-machine interfaces, safety, simulation, special missile considerations, and rotary wing concerns in the interests of time. But if you take that group of disciplines, you can come up with four rather dramatic examples of what the future will hold for us if we persevere along the lines that we have in the past.

Either military or commercial, cargo or passenger, aircraft will be able to save up to 50 percent of the fuel that they now burn carrying a given payload a given distance.

Second, military aircraft involving many of the C^3 I missions—the new command, communications-intelligence missions—will be able to remain aloft unrefueled for somewhere between 24 and 120 hours, which will be a very valuable military addition.

Senator CANNON. Are you talking there in terms of no additional tankage?

Mr. CLEVELAND. Fundamentally by comparison, with no additional tankage and without refueling—very long endurance possibilities which may embrace alternate fuels—new cryogenic fuels or something we have not even invented yet.

Third, we will be able to fly strategic missions or commercial missions over considerable ranges at Mach numbers between 3 and 6. We do not know how to do that in a fashion that is costeffective yet, but someday we will. That will be important to our economy but it will also be very important to the survivability of combat aircraft.

The fourth example is in the general area of V/STOL improvements where we will someday be able to operate aircraft that have real utility from very small ships, which can have a profound effect on Navy strategy and Navy flexibility, and we can have assault troop carriers for deep penetrations with large payloads for special missions such as the abortive Iranian rescue.

In a word, our future potential is enormous.

Now let me turn to the second issue. This is a favorite. Why is aeronautics unique and deserving of special treatment, sometimes too often abrasively referred to as a subsidy, relative to many industries which receive no such special attention? Specifically the statement is made that industry will pick up the slack and do those things which are no longer possible by an underfunded NASA.

Our response is one of simple self-interest and economics, which are the cornerstones of our free enterprise system. Many of these things have been alluded to earlier this morning, I was pleased to see, and I shall thus hasten through them.

The first hurdle is one of cost and duplication. Virtually every one of these companies is involved in, or are following, NASA's programs in their entirety, whether in their own laboratories or as subcontractors. Each of us is probably doing some independent work in the same areas, but with the dozens of disciplines and programs there is no way in which each of us could be carrying the entire burden of progress in all of the disciplines that each of us thinks may have a future path.

You see, NASA has a tremendous sharing system, alluded to earlier, so that their programs are published by both formal and informal means, reducing enormously what we each would have to do without them. Even if each of us could afford to carry that burden, we would be extremely reluctant to share it with our competitors. That is a part of the system, and a proper one which has its own great virtues.

NASA brings a kind of a holy water to this ritual. They pay and they demand appropriate sharing to which we all, grudgingly sometimes, accede. We would, of course, run out of both the kinds of trained people and the facilities that would be needed if we were all trying to duplicate all of those programs.

Now the problem of cost of duplication is exacerbated by another condition, and that is uncertainty. Mr. Demish was the first one, I think, who recognized this very well. Each of us in the industry must proceed with a given program in a given technical discipline to learn four things:

First, whether the goal sought in the particular area is technically possible at all. Second, after we have gotten to a point where we think we are making that technical progress, we must then find out if it is going to be economically feasible. Then we have to be sure, with all due respect to the Congress, that there is no new law or regulation which affects the acceptability of the solution that we are developing.

Finally and most important, no matter how apparently attractive the economics, the regulatory acceptability, and so on, will the user market accept the particular solution we have developed? I have one clear example here:

Would the public accept and flyon a brand new prop-fan commercial transport at Mach .8 if the same speed aircraft were offered to them alternatively without propellers but with higher fares? I am glad I am not the chairman of a company who has to someday make that kind of decision.

Now when you extrapolate these four uncertainties in every area where we rely on NASA for leadership, and recognize that each company must be doing its own thing on each, the preposterous nature of the assumption that we in industry can afford to perform NASA's crucial function becomes clear.

Let me quote briefly from page 3 of a publication of February 1982 of the Office of Management and Budget—the budget cutters in this case. This is their special analysis K of the budget for 1983 and it says: "The Government should focus its direct R. & D. support on those areas where there is national prospect for significant economic gain to the Nation but where the private sector is unlikely to invest adequately in the national interest because the benefits in large measure are not immediately appropriable by the individual firms."

This is a brandnew publication dealing with R. & D., explaining, by OMB, the 1983 budget. It sounds as if the policy is willing but the execution is weak.

NASA's charter gives it substantial independence, particularly in the long-term research areas. This independence is essential and it cannot be transferred to industry, or to the military or to anyone else. NASA publication of a report or of data gives that material an imprimatur which enhances considerably its acceptance by the FAA, by the military services, by commercial airline customers, by foreign goverments and by foreign airline customers—very important to us and to each of them.

Again on independence, military requirements or needs—at least those which receive near-final official endorsement—do not spring like Phoenix from the ashes. There is a closed loop in which requirements are specified generally only after the possibility of some new capability has been developed by someone else or by the military themselves.

Though occasionally the requirements may precede and be a stimulus to the research and development focus, the greatest steps forward have come from totally independent research uninfluenced or stimulated by any requirements notion.

Let us see just for a moment what NASA does as measured by applicability to the needs of the Nation's security. My colleagues and I have taken a complete list of NASA R. & T. in systems technology programs for 1981 through the first indenture below the title of those programs and we have tried to classify them in terms of applicability to military utility, and we have used four grades: first, farthest to the left, "certainly not;" second, "dubious;" third, "possible or likely;" and, fourth, "clearly applicable."

Adding the first two scores, the "dubious" or "certainly not," we find that only 11 percent of the total of those programs were pretty unlikely to be militarily significant, which leaves 89 percent on the other side, as having reasonable or excellent chances of being valuable to the Department of Defense, if not now, at least some day in the future.

I would like to amend my written statement by the addition of that table to the testimony, if I may.

Senator SCHMITT [presiding]. Without objection that will be allowed.

Mr. CLEVELAND. Now that is really a lead-in to the last issue. Why not turn NASA and its people and its facilities and some portion of its responsibilities over to the Department of Defense? I shall not belabor the answer since so many parts of it have been implied in what you know and what many others have said.

In the first place, of course, the Department of Defense clearly wants NASA to remain substantially as it is. It has never expressed a desire to undertake their charter responsibilities. DOD has an entirely much shorter term attitude toward most of their endeavors which would be disastrous if applied to longer term thinking. Independence of thought in wondering, in imagination and in speculation is a keystone of the great Gestalt's of our time.

Harking back quite a few years, Einstein sought knowledge and understanding, not nuclear weapons. Isaac Newton's inspiration was not targeted toward an understanding of planetary motions but the basic relationships among force, mass, and acceleration. The entire current field of genetic engineering was originally developed by people seeking knowledge, not the solutions to problems in transplantation of human organs, enhancement of agricultural foodstuff productivity, or the solution of certain major pollution problems, problems which are clearly going to succumb to their work.

And, of course, flexibility is a major element of independent. NASA enjoys that to a degree not typical of most Government organizations.

This also speaks to the subject that occurred earlier, I believe the chairman brought it up, with regard to having DOD pay for the use of NASA facilities, which is, at first blush, economically attractive. I think that at least one major problem would be the application of the Golden Rule: "The gent who has the gold makes the rules" and this would imply considerable DOD control and decisions with regard to the use of those facilities and would have implications with regard to the independence of which I spoke earlier.

It seems to me that there are a couple of people who have described very well some of the elements of our situation. You will remember Satchel Paige warned us not to look back. Someone may be catching up with us. Well, he could not possibly be more correct. Our foreign competition is doing that. They have advanced from about 5 percent to 30 percent of the commercial wide-body market in less than 10 years. To support some comments that were made earlier with regard to MITI, the Japanese Ministry of International Trade and Industry, I would like to read a direct quote from their MITI policies for 1981, which is:

> Subsidies shall be continuously provided for the development of the next civil transport plane, the Y-X. Following the Y-X the development of another civil transport plane, the Y-XX, shall be investigated, with the aim of promoting the aircraft industry, whose important role has been recognized as an advanced technology industry.

Well, Winston Churchill did not intend to preside over the dissolution of the British Empire. My colleagues and I trust that this Congress and this administration will not find themselves presiding over the dissolution of U.S. preeminence in aeronautics.

Thank you.
[The statement follows:]

STATEMENT OF F. A. CLEVELAND, VICE PRESIDENT, ENGINEERING, LOCKHEED CORP.

My name is Al Cleveland. I am Corporate Vice President, Engineering, for the Lockheed Corporation. I have been involved in aeronautical research, technology and development programs steadily since 1944. Speaking for the five of us from industry, we are very appreciative of this opportunity to appear before you. Though I have been asked to make a summary statement on behalf of all of us, we are all here to augment or explain any of the written testimony we have submitted and to engage in whatever dialog you desire.

In the interest of conserving your valuable time, I do not intend to start at the introductory level by haranguing you at length with the familiar. I will thus mention only a few truisms with which I know you are as acquainted as we. Then I will proceed to some of the more specific and aggressive challenges which are made to our industry and to NASA by those who wish to cut both muscle and bone in NASA's aeronautic budget.

Thus, I offer, only for the ask of completeness, reiteration of the fact that the government is responsible for our national security; it is vitally concerned with balance of trade; the nation's economy is dependent on a spendid air transportation system; the government and its economics, taxes, and entitlement programs are totally enmeshed in jobs and employment; and both it and its people are concerned with the nebulous but real benefits of national prestige. Every one of these is profoundly affected by NASA's work. They are totally important and I know you are totally aware of that importance. In fact, even the budget cutters seem to agree here, while at the same time planning a reduction in constant 1980 dollars to only 56 percent of the 1980 budget by 1983.

I intend to treat those five topics—national security, balance of trade, air transportation system, jobs, and national prestige—as what we in the technical world refer to as "givens." We'll be happy to explore them further at your pleasure in the subsequent dialog and we have, in fact, addressed them in varying degrees in our written testimony.

But we's like to tackle some tougher issues with you today. For the sake of orderliness, it would seem that the first issue is fairly obvious: Is there enough room for further progress of substance in aeronautics to make research and development investments by anyone—NASA, industry, or DOD—worthwhile and cost effective, Somehow the aeronuatics community has managed to give the impression of success in technological progress to the point of diminishing returns: the performance of our military products and the economic capabilities of our commercial ones have led many to believe that few further gains are possible, giving us the external trappings of a technologically mature industry. This at a time when we are really still in our teens, if not our infancy, technically. Let me illustrate.

Perhaps the first thing you would expect us to understand absolutely, and to calculate accurately, is the behavior of air flowing around an aeronautical vehicle, that is, aerodynamics. We can do much more today than in the past but, despite the efforts of some of the best minds of our time, turbulence aerodynamics is still incompletely understood. This includes the one special component of it of great concern around airports—noise.

Materials of construction of our airplanes remain in many ways a metallurgical black art. The arrival of composites has created an entirely new ballgame where even our present uncertain metallurgical knowledge is grossly insuffiicent. The new metal matrices make us use some ignorance in both camps. Fracture mechanics, dealing with repeated material stressing during crack nucleation and growth, is quite new and demands substantial research progress.

High temperature materials, usually involving some strategically scarce alloying elements, are a special consideration. Turbine inlet temperature increases as much as 400 degrees Fahrenheit are within sight. The internal aerodynamics of turbine engines hold promise similar to that for external aerodynamics of the vehicles. Really efficient propulsion for vertical or short takeoff and landing has not yet really arrived. Alternate fuels are a story in themselves, particularly if cryogenics are considered, where synergistic applications to promote laminar flow control or to provide the structural cooling for hypersonic flight may be developed.

Relatively new to the aeronautics community is the application of today's burgeoning electronic devices and systems in sloving non-electronics problems. Drag reductions from the introduction of artificial stability have great promise, structural weight saving by reducing loads will improve aircraft efficiency, or battle damage tolerance may derive from this technique; four-dimensional navigational concepts should have considerable military application. Structural dynamic and aerodynamic problems of rotary wing vehicles will in some cases succumb. All in all, many improvements in aircraft subsystems—propulsion, hydraulics, electrical and pneumatic—will result.

I have intentionally, in the interest of time, skipped or relied on implication to cover many other areas such as man/machine interface; safety; simulation; and special missile concerns.

Now to really answer the question we asked, we must indicate some gains in performance and/or economics which will certainly accrue from some combinations of progress in those and other examples.

First, Either military or commercial, cargo or passenger, aircraft will be able to save up to 50 percent on the fuel consumed for a given mission. While our propfan program is being seriously cut back, the French are in the third year of their own program, and the Russians are predicting such propfans entering into their service in the early 1990's.

Second, Military aircraft involved in warning, communications, antisubmarine warfare over-the-horizon radar operation, battle management and the like will be able to remain aloft for periods somewhere between 24 to 120 hours without refueling.

Third, Strategic missions of great range will be flown at speeds between Mach three and six, substantially enhancing their survivability in combat.

Fourth, Adequate V/STOL improvements could result in aircraft able to operate from very small ships, having profound effects on Navy flexibility. The same technology could permit creation of an assualt troop carrier which could do deep penetrations in special missions such as the abortive Iran rescue.

Now let me turn to the second issue. I think we all understand the general thrust of the OMB challenge. Why is aeronautics unique and deserving of special treatment (sometimes abrasively referred to as a subsidy) relative to many industries which recieve no such special attention? More specifically, this gauntlet is often flung down accompanied by the statement that industry will pick up the slack and do those things which are no longer possible by an underfunded NASA. The answer is one of simple self-interest and economics, the cornerstone of free enterprise.

The first hurdle is one of cost and duplication. Virtually all of us in industry are not only following the work being pioneered by NASA at any instant, being done partially or wholly in their own laboratories or by subcontracting to one or several of us. Each of us is probably doing some independent work in the same area; but I am talking about perhaps dozens of disciplines and programs in this regard, and there is no way in which each of us could be carrying the entire burden of progress in all the technical disciplines we think may have a future payoff.

You see, NASA has a tremendous sharing system so that the work they do, or that several of us do for them, is published and distributed by both formal and informal means, reducing enormously the otherwise duplicated work we would each have to perform without a NASA. If we each carried such a financial burden I must tell you that we would be extremely reluctant to share it with our potential competitors. NASA, on the other hand, brings a kind of holy water to the ritual. They pay and they demand appropriate sharing, to which we all, grudgingly sometimes, accede. We would, incidentally, run out of people and out of facilities as well. There is just no practical way to make this work in our American system.

This cost-of-duplication problem, however, is exacerbated by another condition—that of uncertainty. Each of us in the industry must ask, and by proceeding with a given program in a given technical discipline, learn: first, whether the goal sought in that particular area is technically possible. After enough progess is made to determine that to a reasonable degree, we then must find out if it is economically feasible; that is, will it be worth what it costs us to actually incorporate it in one of our vehicles? By the time we have gotten that far, we have to check and be sure that somebody has not passed a new law or regulation which will have some significant effect on the acceptability of our solution. Subsequent to that, no matter how apparently attractive the economics of our solution, will the user market actually be there and will it accept the particular solution that we have developed? For example, would the public accept and fly on a brand new propfan commercial transport at Mach 0.8 if the same speed aircraft were offered to them alternatively without propellers but with higher fares?

When you extrapolate the four uncertainties I have described in every one of the many areas in which we currently rely on NASA for their classic leadership, and when you recognize that each of our companies must be largely be doing its own thing on each of them, it takes little imagination or projection to realize the preposterous nature of the assumption that we in industry can afford to perform NASA's crucial function.

I must digress a moment to enlarge a bit on NASA's rather special characteristics which are so important to total aeronautical progress, both civil and military. Their research for the military gives both itself and industry direct access to military results when they can be made available and are applicable to other programs. Their interpretation work tends to be elegant, thorough, and basic. They have the ability and the desire to dig further into the problems that are identified while doing work for the military and they thus go out to all the corners of a particular envelope and also fill in all the chinks in the middle. They have an excellent distribution system that gets the data into many hands very quickly. You know the uniqueness of their facilities and the first-class work which they permit; but NASA's skills and expertise are very high and, in fact in some areas, simply superior to the skills in industry or the military establishments.

NASA's charter and budgets have always been based on substantial independence in their work, particularly in long-term research areas. It is essential that this independence remain and that no one try to transfer that responsibility to industry, to the military, or to anyone else in this country. NASA publication of a report or of data gives that material an imprimatur which enhances considerably its acceptance by the FAA, by the military services, by commercial airline customers, and by foreign governments and foreign airline customers, a type of endorsement extremely important when we are trying to sell to foreign countries.

Referring again to the statement on independence, I am sure you share our understanding that military requirements or needs, at least those which receive official endorsement, do not really spring like Phoenix from the ashes. There is a closed loop cycle in which requirements and needs are specified only after the possibility of some new capability has been developed. Though those requirements may be a stimulus to research and development focus, some of the greatest steps forward have come from totally independent research, which generated a new capability representing an enormous step forward, totally uninfluenced or stimulated by any requirement notion.

Let me develop this point a little further in terms of the kind of research and development that NASA does as measured by its possible applicability to the nation's secrurity, that is, to DOD future programs. My colleagues and I have taken the complete list of NASA programs for 1981 through the first indenture below the general subject area, for both research and technology and for systems technology. We created a classification of each of those programs in terms of possible military utility, ranging from "certainly not" to "dubious" through "possible or likely" to, finally, "clearly applicable." When we had finished our grading—and I can only assure you that we were as fair and careful as we knew how to be—we found that we had the following scores. Out of a total of 84 items to be judged, we had 2 which fell in the "certainly not" category; 7 which were "dubious"; 21 which were "possible or likely"; and 54 were "clearly applicable." If one adds the first two scores together you must conclude that 11 percent of the total were pretty unlikely to be militarily significant, leaving 89 percent as having reasonable or excellent chances of being valuable to the Department of Defense—if not now, then some day in the future.

That's a lead-in to the next question: "why not turn NASA, its people, its facilities, and some portion of its responsibilities over to the Department of Defense?" I shan't belabor the answer or answers to that question since so many of them have been implied in what you know and what we and many others have said. In the first place, the Department of Defense clearly wants NASA to remain substantially as it is and have never expressed a desire to undertake their charter responsibilities. DOD has a much shorter term attitude toward most of their endeavors and this is entirely proper, but it is disastrous if it paralyzes longer-term thinking. Independence in thought, in wondering, in imagination, and in speculation is a keystone of the great gestalts of our times.

Albert Einstein sought knowledge and understanding, not nuclear weapons. Isaac Newton's inspiration was not targeted toward an understanding of plantery motions, but the basic relationship among force, mass, and accelaration. The entire field of genetic engineering was developed by people seeking knowledge, not solutions to problems in transplantion of human organs, enhancement of agricultural foodstuff productivity, or solution of certain major pollution problems. And of course, flexibility is a major element of independence. NASA enjoys that to a degree not typical of most government organizations.

Gentlemen, it seems to me there are a couple of people who have described very well some elements of our situation. Satchel Page warned us not to look back—

someone may be catching up with us. He couldn't possibly be more correct—our foreign competition is doing just that, commercially and militarily. My colleagues and I hope that you will not have to witness the disappearance of U.S. preeminence in aeronautics. Thank you.

Attachment.

NASA AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

NASA has provided the enclosed detailed listing of their Aeronautical Research and Technology Program, indentured under the two main headings of "Research and Technology Base" and "Systems Technology Programs."

We have been as honest as we know how in evaluating the present and potential applicability of these programs to miltiary needs. The categories used in this evaluation are:

A—No military application of the present work.

B—Highly dubious that the work could have military application.

C—Possible future military application, particularly if the work were re-focused on military needs, though that is often not necessary.

D—Clearly has future military application.

NASA AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM

[Key: A—None; B--Dubious; C—Likely; D—Clearly]

	Military application			
	A	B	C	D
1. Research and technology base:				
1.1 Aerodynamics R. & T.:				
Computational fluid dynamics (includes NAS)				×
Viscous flow				×
Airfoil aerodynamics				×
Component interaction				×
Experimental methods				×
Supersonic/hypersonic aerodynamics				×
Wake vortex				×
Cryogenic test facility				×
1.2 Propulsion R. & T.:				
Noise reduction		×		
Inlets and nozzles				×
Turbomachinery components				×
Internal computational fluid dynamics				×
Combustion and fuels				×
Power transfer/mechanical components				×
Engine dynamics and controls				×
Hypersonic propulsion				×
Instrumentation				×
1.3 Materials and structures R. & T.:				
Composites				×
High-temperature engine materials				×
Life prediction				×
Aeroelasticity				×
Structural analysis and design			×	
High-temperature structures				×
1.4 Controls and guidance R. & T.:				
Navigation and guidance			×	
Crew station technology				×
Aircraft controls				×
Integration and interfacing technology			×	
1.5 Human factors R. & T.:				
Human response to noise		×		
Flight management				×
Simulation technology			×	
Aviation safety			×	
Workload/performance measurement				×
1.6 General aviation R. & T.:				
Aerodynamics and flight dynamics			×	

NASA AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM—Continued

[Key: A—None; B—Dubious; C—Likely; D—Clearly]

	Military application			
	A	B	C	D
Crash dynamics and structures		X		
Propulsion			X	
Avionics and controls		X		
Pilot/aircraft interaction				X
Low-speed propeller		X		
Aerial applications (agricultural)			X	
1.7 Low-speed R. & T. (rotorcraft):				
Aeroacoustics			X	
Loads and structures				X
Flight dynamics				X
Configuration research				X
1.8 High-speed R. & T.:				
Powered lift				X
Flight dynamics				X
Aero/propulsion integration				X
Interagency assistance and testing				X
High-speed structures				X
Supersonic aerodynamic configurations and integration				X
High-speed controls				X
Hypersonics				X
1.9 Transport R. & T.:				
Fire safety			X	
Crashworthiness			X	
Meteorological haza[illegible]			X	
Aircraft/runway interf[illegible]			X	
Aircraft operating conditions	X			
Icing			X	
2. Systems technology programs:				
2.1 Systems studies				
2.2 Materials and structures:				
Materials for advance turbine engines				X
Integrated program for aerospace vehicle design			X	
Aeroelasticity of turbine engines				X
Turbine engine hot section technology				X
2.3 Propulsion:				
Advanced low-emission combustion		X		
Helicopter transmission technology				X
Broad property fuels				X
2.4 General aviation:				
Advanced avionics systems		X		
Commuter aircraft technology			X	
2.5 Avionics and flight control: Advanced guidance and control systems			X	
2.6 Low-speed:				
Rotorcraft operating systems				X
Powered lift technology				X
Advance rotor system tech/RSRA ops				X
TRRA systems technology				X
V/STOL systems technology			X	
Advance rotorcraft technology				X
Low-speed simulating and fitting systems support				X
2.7 High-speed:				
Supersonic cruise research			X	
High-performance flight research				X
Highly-maneuverable A/C technology				X
2.8 Transport:				
Laminar flow control				X
Energy efficient transport			X	
Composite primary A/C structures				X
Terminal configured vehicle	X			

NASA AERONAUTICAL RESEARCH AND TECHNOLOGY PROGRAM—Continued

[Key: A—None; B—Dubious; C—Likely; D—Clearly]

	Military application			
	A	B	C	D
2.9 Advance propulsion:				
Energy efficient engine			×	
Advance turboprop systems				×
Variable cycle engine technology				×

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. What are the effects or do you expect the effects to be of the Economic Recovery Act on the U.S. aeronautics industry research and development?

Answer. The Economic Recovery Tax Act of 1981 (ERTA) contains the following provisions with respect to industry R&D:

A. The Act allows corporations a charitable deduction for contributions of newly manufactured scientific equipment to universities for research use equal to the taxpayer's basis plus 50 percent of the appreciation, but not to exceed twice the basis.

B. The Act provides a 25 percent income tax credit for certain qualified research expenditures to the extent such expenditures exceed a base period amount.

C. For two years, taxpayers are required to allocate expenditures for research and experimentation conducted in the United States entirely to U.S.-source income. This is beneficial inasmuch as it helps the contractor's tax credit condition by preserving the level of his foreign source income because his foreign source income need not be reduced by a portion of the R&D expenditures. This feature should be extended beyond the current two year limit.

These features of the Act are, indeed, incentives to the accomplishment of increased R&D. However, the impact of these features of the ERTA are as yet unknown. It will be very difficult to measure the extent to which a company is influenced to increase R&D expenditures solely from these incentives inasmuch as they are only one of many variables that must be considered when determining R&D budgets.

Question 2. What access do you have to DOD programs as compared to NASA? Are there time differences in acquiring DOD related program data as opposed to NASA? If so, what are these differences?

Answer. The access to DOD programs is more limited when compared to NASA. For security reasons access to many DOD programs is allowed only with an established "need to know." Although some information symposia are sponsored by DOD, the primary source of data is progress and final reports, most often with restricted distributions. DOD technical information availability varies with organization and informational requests from industry generally need to be very well defined. Security issues often obscure the proper organization to whom such requests should be directed. NASA, on the other hand, encourages industry-wide information briefings and widely and promptly disseminates its reports. This freedom, which NASA fosters, provides for considerably greater and more timely access to technical data and programs for industry.

Question 3. What percentage of your company's gross income is expended on your own R&D efforts?

Answer. Each year the overall Lockheed Corporation invests approximately 2 percent of sales in R&D efforts. In 1981, Lockheed's investment in aeronautical R&D was approximately 1.3 percent of aircraft and related services sales.

Questions 4 and 5 will be answered together.

Question 4. Last year the Committee was concerned about the overall costs for the NASA. Consequently, the Committee asked NASA for a report on the description of the program, the status and to look at funding options. One option explored looks at a joint development program and recovery of capital costs. Could you please elaborate on your concerns about these approaches?

Question 5. How important do you consider NASA's proposed program on the Numerical Aerodynamic Simulator?

Answer. The proposed NASA Numerical Aerodynamic Simulator (NAS) is one of considerable interest to us and one which we feel is of substantial national importance. The concept of having the ability to compute the aerodynamic characteristics of bodies in fluid flow fields, though not new, is of tremendous importance. The work done by NASA along these lines up to the present has constituted a crucial first step in progress toward the ultimate goal.

We foresee that goal as being made up of the ability to predict, with a very high degree of accuracy, the pressures on all elements of bodies in such fields over a wide range of Mach numbers and Reynolds numbers in relatively brief elapsed times. The most important benefit will accrue from the ability to alter the shape of such a complex body as dictated by the result of one series of computations in an effort to improve its shape, and to be able to determine the effects of those changes quite rapidly so that further reiterations can be employed in gradually optimizing the eventual body shape.

The wind tunnel methods employed today remain deficient, principally because the full scale Reynolds numbers characteristics cannot be achieved (or at least not until the National Transonic Facility is available) and even when full scale effects can be reproduced on models, the time and expense involved in modifying one model as a result of the data achieved by its predecessor will remain substantial and will delay, or even defeat to some degree, the optimization process.

If the NAS finally achieves the capabilities which are sought, it will answer a compelling need, both nationally and industrially, because of the facility and efficiency which it would bring to the design process. It would be of great value to industry as well as to NASA itself. It would be invaluable as a research tool, particularly appropriate to NASA's basic character. Even if it lacked some degree of total confidence in accuracy it could be used in preliminary phases to guide the design of the aerodynamic contours, at least to the point where final wind tunnel verification would be much more sharply focused and much less consumptive of wind tunnel time.

We recognize, and urge, that all involved in the decision-making for this development recognize that there is no way to prove that "X" millions of dollars will, even if spent prudently, result in a definable advance in computational aerodynamics. This uncertainty is one of the key reasons why the development should be a NASA charter and why the powerful personnel capability they have in this arena should be applied to this extension of their current progress. The cutting edge of such work can turn out to be a tremendous contribution; it can also turn out to be a great disappointment, but even in the latter case much will be learned that is useful, and some totally unexpected insights may providentially present themselves. Such rewards are the fruits of research in the classic sense, and this nation has been shortchanged in this regard for many years.

Viewing this matter from a broader perspective, we appreciate the fact that the results of progress in aeronautics will redound to the benefit of the nation in two fundamentally different but important ways. It will bring to our national security an improvement in aeronautical technology by virtue of more speed in accomplishments as well as by better understanding of some of the phenomena with which we deal. It will bring to the civil air transport system the same types of improvements which will ultimately help the entire nation from the commerical viewpoint. Thus we are really speaking to an issue which is of eventual great importance to the American public as its benefits work their way throughout aeronautical technology.

Question 6. What might your position be to changes in the NASA enabling legislation which would permit the recovery of some facility R&D funds by NASA in their user fees for these facilities? What pricing structure would you propose?

Answer. We must take a firm stand against any proposal to permit NASA to recover facility R&D funds through user fees. Taxpayers paid for those NASA facilities; taxpayers should have free use of their own property—at least on an "as available" basis. We recognize there must be some practical restraint on such a philosophy and, therefore, would add that the recommended "free use—as available" access should be limited to those that need such facilities in the peformance of work being done in connection with United States government sponsored effort.

Question 7. What do you believe the proper balance should be between the NASA research and technology base programs and the systems technology programs?

Answer. In our judgment there is no single proper balance between NASA research and technology base programs and systems technology programs. The portion of the total aeronautics budget which is dedicated to each of those major elements will vary to some degree from year to year. The balance will depend on such things as the particular need in one or the other as expressed by the various users such as the Department of Defense, industry, and other portions of NASA itself, and the difference in perception and planning dictated by the fairly dynamic process of dealing with short, medium and long range perceptions of need. It would be presumptuous indeed for one company to express such a desired ratio as either fixed in nature or as being subject to the judgment of a single company in the industry, ignoring all the others who should participate. This is one of the functions which NASA seems to serve so well; they listen carefully to all points of view which have reason to be considered, and then come up with a workable compromise which seems to be reasonably optimal under the exigencies of conflicting desires.

Question 8. It's acknowledged that the number of foreign transport aircraft produced (and) is being sold each year (is increasing). What percentage of these aircraft contain U.S. parts and materials, i.e., power plants, avionics, etc. Within each aircraft type what percentage of U.S. equipment is on that type?

Answer. We at Lockheed do not have specific detailed knowledge of U.S. manufactured equipments which are designed into foreign transport aircraft. As a corporation Lockheed is not recently participating in the production of any of these foreign aircraft. An article in the August 1980 issue of Airline Executive indicated that approximately 35 percent of the initial cost of an A-300 is for U.S. manufactured items such as engines, avionics boxes, tires, brakes, etc. This U.S. contribution is reported by the article to grow to 50 percent of the life cycle cost as many of these items require replacement during the expected life of the aircraft.

Question 9. What NASA skills are greater than those available to DOD and industry? Why?

Answer. There are certainly myriad circumstances under which NASA may have skills in particular areas which are greater than those available to DOD and industry. First let me point out that industry is not a single entity and therefore a particular skill in, say, turbulent aerodynamics in one company is not available to another company. The same thing is true to a limited extent in DOD where one laboratory may be quite strong in a particular skill but that does not insure its availability for another laboratory.

This same sort of thing is true for NASA as well but the openness and philosophy of communication and sharing of technology which is inherent in NASA tends to reduce these isolation characteristics. Specifically, however, NASA tends to have very high skill levels that are a derivative of at least three of the fundamental characteristics of NASA. The first is that they have very specialized, high technology, and often unique facilities. This obviously leads to a capability to operate those facilities, and it also results in certain insights into the data products which they produce. These insights are lacking in others who might also be facile in operating the facility but, due to historic unfamiliarity would be unable to recognize some significant trends or troubles in the data forthcoming.

A second characteristic which leads to very high skills is the long term research orientation of NASA. We have discussed earlier in our testimony the fact that this is a fundamental attribute of great value to the nation, including both DOD and industry. That long term bias leads to having more people working nearer the cutting edge of any given technology which is under NASA's purview. Because such basic long term research is encouraged and supported, the people who are doing the work have the ability and the freedom to delve more deeply and to progress farther into basic understandings of whatever the discipline is they are pursuing.

That comment about freedom reflects directly on another point we made earlier in our testimony which has to do with NASA's independence. They retain the right to listen to the needs expressed by all about them, and then decide, to a very large degree on their own recognizance, on just what paths they shall pursue, using what methodologies, what resources, etc. This ability to be independent, properly coupled with a feeling of responsibility to be responsive to the needs of users, is a characteristic not easily developed and fragile to preserve. It has led to some of NASA's most significant progress over the years.

Question 10. What is the government-industry relationship in France with respect to the turboprop development program? We would appreciate details to the extent of monies appropriated, program goals and schedules?

Answer. Unfortunately we have no detailed information to give you at this time on schedules, goals, or monies appropriated for the turboprop development program in France. We are pursuing this line of inquiry with some of our French contacts and will be pleased to forward additional specifics to you as soon as we receive them. We do have reason to believe that the program is developing as a joint government-industry effort. Further, we have been informed that the Office of National d' Etudes et de Recherches Aerospatiales (ONERA), the French NASA, has contracted with Aerospatiale for a wind tunnel test of a one meter propfan model.

Senator SCHMITT. Thank you, Mr. Cleveland. Would you not agree, though, that indirectly DOD is now controlling NASA aeronautics R. & T.?

Mr. CLEVELAND. No, I would not.

Senator SCHMITT. Have you studied the 1983 budget?

Mr. CLEVELAND. There is quite a difference between influencing and controlling.

Senator SCHMITT. Well, DOD thinks they are in testimony before this subcommittee.

Mr. CLEVELAND. The examples I cited of the future applicability of NASA research has a profound support of that by implication. The question is where are the decisions made and how are the decisions made with regard to what work is going to be done in the long-range view, and that is very difficult.

Senator SCHMITT. Well, I agree with you, but I am afraid that what is happening in the budget now is that it is the programs of DOD interest that are being maintained. Those that are not of DOD interest are the ones that are being dropped.

Mr. Parmet, would you proceed, please?

STATEMENT OF NORMAN R. PARMET, AVIATION CONSULTANT, FORMER VICE PRESIDENT OF ENGINEERING AND QUALITY ASSURANCE, TRANS WORLD AIRLINES

Mr. PARMET. Mr. Chairman and Senator Cannon, I am Norman Parmet, an aviation consultant. I have recently retired as vice president of engineering and quality assurance for Trans World Airlines and am probably the only one here who in anyway might represent the operational aspect of commercial aviation.

Since my retirement I have been active as a consultant to the aviation community and this is my first visit before your committee, and I am certainly pleased that I have the opportunity to be here today.

For a number of years I was a member of the NASA subcommittee on aircraft operating problems. This group, which comprised a cross section of the aviation community, was constituted to advise NASA as to the type of programs it should pursue to serve the aviation community. Recently and since that time, since my retirement, I have been appointed to NASA's Aerospace Safety Advisory Panel, which was established by congressional directive to advise NASA management on policies, practices, operational procedures, and design concepts that are related to the maximum feasible safety level for operation of its manned and unmanned flight programs.

I spent 34 years with TWA and during this period I served in a number of disciplines, but over 20 of those years I was associated with or directly responsible for new aircraft development from the user standpoint.

I think there is little understanding outside the industry of how hard the airlines have worked in the past to encourage and contribute to the development of the best possible vehicles and working with the manufacturers and with NASA. The evaluation of these new types of aircraft by an airline require pretty extensive efforts. Long before the manufacturer develops designs for new airplanes there are continuing dialogs generally between the manufacturer and a potential customer as to what the vehicle should do.

The airlines, in their contacts with NASA and industry, try to instill ideas of what needs to be developed and are busy trying to obtain feedback on what was being done in that field. Such interaction led to airplane design concepts which have always been aimed at improving the next generation of vehicles.

Even before any airplane design is committed to production the major airlines in particular will have conducted extensive evaluations of the physical, operational, and economic characteristics of each candidate vehicle. This includes projecting operating costs across the expected life of the vehicle. The military refers to this as life cycle costs, but we were doing it long before we ever heard that nomenclature.

We fly the airplanes with paper designs in our computers. We evaluate structural and systems concepts, and all of this leads to an economic evaluation as to the direct operating costs of new vehicles. The comparison of one vehicle to another generally leads to a purchase selection, or it has in the past. With the new factors that are brought up today, quite frequently finance has a major impact.

Going back to my train of thought, however, for manufacturers to produce excellent designs there needs to be a close working relationship among the manufacturers, NASA and the commercial airlines. Such a relationship has existed for many years, indeed decades, and has resulted in the development of the best commercial airliners in the world.

As has been said a number of times this morning, this country has led the world in the sale of the best vehicles offered anywhere. They were superior in every way under any comparison. One has but to look at the history of sales over the past few years to see this change that is occurring with the resultant erosion of the American share of this marketplace.

Foreign governments are fully supporting their aviation manufacturers. The word subsidy has been used quite frequently this morning. I have got to say that the vehicles being manufactured and developed in Europe have become very highly competitive with their American counterparts. No longer is there this easy superiority that the American industry has always enjoyed.

When this superiority disappears and you are dealing on the basis of technical equivalency, then the decisions are frequently made on a financial basis. In effect, American industry is competing against foreign governments and that is why we see more and more foreign manufactured airplanes appearing in this country in the colors of U.S. airlines and overseas airlines which for years have been coming to the United States are buying overseas as here and elsewhere.

I know from firsthand experience that the vehicles being offered by overseas manufacturers are now on a technical level with those being offered by U.S. manufacturers. The most recent equipment selection decision at TWA in which I was involved was the result of a very close and heated competition. The debate over that competition made it clear to me that U.S. aviation industry must not only sustain technical equivalence with foreign competition but has got to exceed it in order to offset the well-known financing advantages available to foreign competitors by their governments.

Let there be no doubt in the minds of any committee members that major United States and world airlines will swing heavily toward foreign aircraft suppliers unless our industry meets and beats the overseas people technologically.

One example of where we have got to beat the others is in the fuel barrier. As you are no doubt aware, each of the five major U.S. airlines spend over $1 billion each for turbine fuel each year. You can well imagine the emphasis being placed on fuel economy through all of the various potentials—operating procedures, maintenance practices and particularly the inherent design capability of the vehicle.

Let us just consider: if any one airline of these five were able to reduce its fuel-burn cost by 5 percent through more efficient vehicles or more efficient operation, $50 million would go to the bottom line of their profit-and-loss statement, and in most cases that would mean the difference between red ink and black ink. I can assure you that that is a fact.

Since deregulation has opened up the marketplace to much greater competition and with the resultant pressures for fare reductions, it becomes increasingly important that concurrent reductions in operating costs be achieved. Obviously there is more than one way to do this.

One of the most important is through the technical achievements such as lighter and better structures, more advanced controls, better aerodynamics, more advanced propulsion systems, greater reliability, and I will not forget increased productivity of the airline operation itself, because that is very important.

Those are ways in which I think we can begin to keep our airline system viable. NASA has made its share of contributions to the superiority. I believe that NASA's contributions must continue.

I have looked at the overall NASA budget and I note that the requested 1983 budget figure of $232 million is considerably less than that authorized for 1982. Within the total figure projected for 1983 the research and technology base is a planned increase from $162 million to $182 million. This is a sound move and I hope it indicates a trend.

The balance of $50 million on which I expect to focus is designated for system-technology programs. In 1981 this was budgeted at $137 million and this represents a planned decrease of 63 percent in 2 years. It is alarming to me in light of two factors—(1) the foreign country support and, (2) the $50 million that is allocated appears to support only military objectives.

Gone from the 1983 budget are all of these programs that were oriented toward civil aviation. I will repeat them: aeronautical systems studies; materials and structures systems technology; propulsion system technology; avionics and flight controls systems technology; general aviation systems technology; transport aircraft systems technology; advanced propulsion systems technology.

For the life of me I find it difficult to understand how the military, with its own projects, must require all of NASA's systems technology, leaving none for commercial programs which probably cannot be supported privately.

Such action, if carried out, will add greater risk to our dwindling worldwide leadership in commercial operation and can threaten the foreign trade balance produced by U.S. aviation sales overseas. That has been stated by experts prior to me.

Because I have restricted my comments to systems technology, I do not want to ignore research and technology base. It is important to understand, however, that the R. & T. base is aimed primarily at long-range projects that are typically 10 to 20 years in the future. This may be too late to serve an industry and national need deprived of the systems technology program which can produce tangible results in a shorter period of time within this decade.

There must be a new look at the apportionment of funds for systems technology programs, and I believe, Mr. Chairman, that I am addressing the people whose vision is clearest to achieve such a new look.

These briefly are my views. If you have any questions I hope I can give you satisfactory answers.

[The statement follows:]

STATEMENT OF NORMAN R. PARMET

Mr. Chairman and members of the committee, I am Norman R. Parmet, an aviation consultant. I have recently retired as Vice President, Engineering and Quality Assurance for Trans World Airlines. Since my retirement, I have been active as a consultant to the aviation community and am self-employed. This is my first visit before your Committee. I am pleased to have the opportunity to comment on the proposed budget for NASA aviation programs.

For a number of years, I was a member of a NASA subcommittee on aircraft operating problems. This group, which comprised a cross section of the aviation community, was constituted to advise NASA as to the type of programs it should pursue to serve the aviation community. Recently, and since my retirement, I have been appointed to NASA's Aerospace Safety Advisory Panel which was established by Congressional directive to advise NASA management on policies, practices, operational procedures and design concepts to achieve the maximum feasible level of safety for its manned and unmanned flight programs.

My career with TWA spanned 34 years. During this period I served in a number of disciplines. For over 25 years, I have been associated with or directly responsible for new aircraft development. At TWA we worked with the manufacturer to encourage and to contribute to the development of the best possible new aircraft and its systems to meet the airline's needs.

The evaluation of new types of aircraft by an airline requires extensive effort. Long before the manufacturer develops designs for new airplanes, there are continuing dialogues between the manufacturer and the potential user as to the objectives of such a vehicle. The airlines, in their contacts with NASA and industry, try to instill ideas of what needs to be developed and obtain feedback on what is being done or will be done in that field. Such interaction leads to airplane design concepts which are aimed at improving the next generation of vehicles.

Even before an airplane design is committed to production by the manufacturer, an airline will conduct extensive evaluations of the physical, operational and economic characteristics of each candidate vehicle. This includes projecting the operating costs across the expected life of the vehicle. The military refer to it as "life cycle cost" analysis, but we've been doing it long before we ever heard that terminology.

Such evaluations require the use of sophisticated computer programs to "fly" the paper design airplanes. Structural and systems concepts receive extensive scrutiny and evaluation. All of this leads to an economic evaluation that projects direct operating costs of the proposed new vehicle. Here the comparison of one vehicle to another leads to a purchase selection.

For manufacturers to produce excellent designs, there needs to be a close working relationship among the manufacturers, NASA and the commercial airlines. Such a relationship has existed for many years, indeed decades, and has resulted in the development of the best commercial airliners of the world. The U.S. manufacturers, for many years, had captured the lion's share of the marketplace. The vehicles that they offered were superior in aerodynamics, in structural design, in system concepts, in reliability and durability, and as a result were superior economically.

One has but to look at the history of aircraft sales over the past few years to see a change, with a resultant erosion of the American share of this marketplace. Foreign governments are fully supporting aviation manufacturers in Europe. The vehicles being developed and manufactured in Europe have become highly competitive with their American counterparts. No longer do the products of American manufacturers have the clear advantage of technical and economic superiority. When such technical and economic advantages disappear, then decisions for airplane selection may be made primarily for financial opportunities offered. In such cases private American industry is competing, in effect, against foreign governments. As a result, airplanes designed and manufactured overseas are appearing in increasing numbers wearing the colors of U.S. airlines. Overseas airlines, which had for years come to the United States for airplanes, are buying less in the United States and more elsewhere.

I know, from firsthand experience, that the vehicles being offered by overseas manufacturers are now on a technical level with those being offered by U.S. manufacturers. The most recent equipment selection decision at TWA in which I was involved was the result of a close and very heated debate. That debate made it very clear to me that the U.S. aviation industry must not only sustain technological equivalence with foreign competition but must exceed it to offset the well-known financing advantages available to foreign competitors by their governments. Let there be no doubt in the mind of any Committee member that major U.S. and world airlines will swing heavily toward foreign aircraft suppliers unless our industry meets and beats that technological competition I will underscore that statement with one example wherein advanced technology can be decisive.

As you are no doubt aware, each of the five major U.S. airlines spends over $1 billion a year for turbine fuel in the operation of its transport fleet. You can well imagine the emphasis which is placed on fuel economy through operating procedures, maintenance practices, and particularly the inherent design capability of the vehicle.

A 5-percent across-the-board improvement in fuel consumption made possible by more advanced technology can mean that a major airline would save $50 million of its fuel bill—a number that would move right down to the bottom line in that airline's financial statement. I assure you it would mean the difference between profit and loss for any airline operating today.

Since deregulation has opened up the marketplace to much greater competition, with resultant pressures for fare reductions, it becomes increasingly important that reductions in operating costs be achieved. This can be done through reduced fuel consumption, through lighter and better structures, more advanced controls, better aerodynamics, more advanced propulsion systems, greater reliability as well as by increased productivity. All this will help in keeping our airline system viable.

NASA has made its share of contributions to the superiority of American commercial air technology. I believe that such contributions must continue. I have looked at the overall NASA budget for Aeronautical Research and Technology. I note that the requested 1983 budget figure of $232 million is considerably less than the level authorized for 1982 or the actual ($271 million) for 1981. Within the total figure projected for 1983, the research and technology base has a planned increase from $162 million to $182 million. This is a sound move, and I hope it indicates a trend. The balance of $50 million (on which I expect to focus) is designated for Systems Technology Programs. In 1981 Systems Technology was budgeted at $137 million. This represents a planned decrease of 63 percent in 2 years. That's an alarming decrease in light of two factors: (1) foreign country support for systems technology appears to be increasing and (2) the $50 million remaining appears to support only military objectives. Gone from the 1983 budget request are all the programs which were oriented toward civil aviation. These were aeronautical systems studies; materials and structures systems technology; propulsion systems technology; avionics and flight controls systems technology; general aviation systems technology; transport aircraft systems technology; and advanced propulsion systems technology.

For the life of me, I find it difficult to understand how the military, with its own huge budget, must require all of NASA's systems technology budget leaving none for commercial programs which probably cannot supported privately. Such action, if carried out, will add greater risk to our dwindling worldwide leadership in commercial operation and can threaten the foreign trade balance produced by U.S. aviation sales overseas.

Because I have restricted my comments to the systems technology budget estimate, I do not want to ignore the research and technology base which appears to be appropriately funded. It is important to understand that benefits from the research and technology base are typically 10-20 years in the future. That may be too late to serve an industry and national need deprived of the systems technology programs which can produce tangible results within this decade—results essential to its technological vitality and its economic viability.

There must be a new look at the apportionment of funds for systems technology programs. I believe, Mr. Chairman, that I am addressing the people whose vision is the clearest for providing such a new look.

These, briefly, are my views. If you have questions, I hope that I can provide a satisfactory answer.

Senator SCHMITT. Thank you. We will get to some questions in a moment.

Senator Cannon, go ahead.

Senator CANNON. Let me ask Dr. Shank, in your testimony here you indicate that an advanced turboprop during the 1990's could save 6 billion gallons of fuel.

STATEMENT OF DR. M. E. SHANK, DIRECTOR OF ENGINEERING, TECHNICAL COMMERCIAL PRODUCTS DIVISION, PRATT & WHITNEY AIRCRAFT GROUP, UNITED TECHNOLOGIES CORP.

Dr. SHANK. Yes, sir.

Senator CANNON. That equates to at least $5 billion. Now if that $5 billion savings were divided equally between the airlines and their paying passengers, it would mean a savings to each group of $2.5 billion, made possible by a NASA 5-year program totaling just under $200 million. That is the estimate of the program cost.

Am I interpreting your numbers correctly on that particular point?

Dr. SHANK. That is one way to interpret them and I think that is a good way to interpret them.

[The statement follows:]

STATEMENT OF DR. M. E. SHANK, DIRECTOR, ENGINEERING, TECHNICAL COMMERCIAL PRODUCTS DIVISION, UNITED TECHNOLOGIES CORP., PRATT & WHITNEY AIRCRAFT GROUP

As a representative of Pratt & Whitney Aircraft, I thank you for giving me the opportunity to comment this morning on the importance of NASA's Aeronautics program. The NASA Aeronautics program through its research and technology has benefited both civil and military aviation. This is an appropriate time to reevaluate the effectiveness of NASA's Aeronautics programs. However, we urge Congress, the Administration and NASA to carefully examine NASA programs and operations in the light of their importance to the strengthening of our economy.

Aeronautics is second only to agriculture in terms of U.S. exports and ranks number one in net exports. Despite large commitments by the U.S. aircraft industry to R&D, there is growing evidence that the once dominant leadership of the United States is now in question. Erosion of this nation's commercial aircraft market has been effected by foreign government-supported industry.

It is imperative that the U.S. maintain its position of world leadership in aeronautics. This will require (1) enormous private resources to finance high technology ventures and (2) a continuing ability to stave off government-supported foreign competition through U.S. leadership in technological achievement. Our government and industry must work together, more than ever, to maintain first place.

NASA has traditionally provided a stimulus to the aeronautical industry by supporting proof-of-concept work. This conceptual technology has shown the way for industry to channel its development resources. Past testimony before this and other committees has provided evidence of NASA contributions to technology in aeronautics which benefited both commercial and military aviation. I would like to recall one proof-of-concept example stimulated by NASA Lewis Research Center which led to the technology developed by our industry in the 1950's enabling compressors to accept a higher axial velocity of the air passing through. That work on the transonic flow compressor became the basis of today's high-efficiency compressor designs. It made possible the modern efficient, high-bypass ratio turbofan, leading to

U.S. supremacy in the engine field. Today, NASA's Energy Efficient Engine program is the proof-of-concept vehicle for new technologies, promising further improved fuel consumption in future engines. And NASA's support of the Prop-Fan concept, with its potentially dramatic fuel savings, could usher in the next significant innovation in aviation history.

For this reason, we at Pratt & Whitney Aircraft were dismayed to learn that the fiscal years 1982 and 1983 Budgets reduced funding in the area of aeronautical research and technology, and that as a result of these reductions, NASA plans to eliminate important program areas. Two programs which NASA plans to cancel are: The Energy Efficient Engine Program and the Advanced Turboprop Program. I would like to comment briefly on these.

The Energy Efficient Engine Program has provided substantiation of many new propulsion technologies. Many of these are being applied in Pratt & Whitney Aircraft's PW2037 engine now under development. Termination of the Energy Efficient Engine (E^3) program would result in loss or significant delay of additional technologies that offer further fuel efficiency benefits to future engines.

An Advanced Turboprop aircraft, using a new prop-fan concept powered by an engine with the latest technology, has the potential of an additional 15–20 percent reduction in fuel consumption for commercial transports. This would have a favorable impact on airline economics. Estimates show as much as 6 billion gallons could be saved by the year 2000 by prop-fan powered aircraft introduced into service between 1990 and 2000.[1] U.S. Military transport studies have also shown considerable advantage in fuel savings and increased operational capability for prop-fan propulsion. The development of this new fuel-efficient aircraft, well ahead of foreign competition, would assure the continuing dominance of U.S. products in the commercial aviation field. Correspondingly, loss of lead time to foreign competition could mean world dominance by products from other nations. Studies have shown that there is a potential swing of $50 billion in trade balance hinging on capturing this market.[2]

This potential for advanced turboprop business has not escaped our competitors abroad. Foreign manufacturers already are pursuing turboprop aircraft. The French are in the third year of their own advanced prop-fan program. The manufacture and test of a prop-fan model is planned for 1984. The Russians are predicting that prop-fan powered Soviet aircraft will enter service in the 1990's, at the same time or even before the West manages to put a production prop-fan into service.[3]

Much up-front proof-of-concept work, now supported by NASA's Advanced Turboprop Program and costing approximately $200 million, needs to be done before the U.S. private sector can undertake a new aircraft for production. the principal proof-of-concept items which must be demonstrated are: (1) cabin noise reduction, (2) propeller structural integrity and aeroelastic stability, (3) gearbox reliability, and (4) systems integration of the propeller, engine and aircraft. Given our industry's near-term funding requirements, it is unlikely that U.S. industry could commit funding for this proof-of-concept work in a timely manner. in addition, in order to utilize this technology, U.S. industry, at its own risk, will have to invest approximately $2 billion of its own money to develop a product and sell it against foreign competition on the world market.

American industry has not lost its willingness to accept the responsibilities associated with the development of high technology, advanced new concepts and products for the market. For example, at Pratt & Whitney Aircraft we have under development our newest, most advanced engine, the PW2037. Its total development cost will exceed $1 billion. Because of increasing competition, industry resources are currently focused on nearer term product improvements. NASA's longer range thinking, planning and support of proof-of-concept testing is essential at this time when industry resources are focused on nearer-term supremacy.

We believe that the NASA funding devoted to aeronautical research and technology should be continued at a $250–300 million level in 1982 dollars. This represents only 4–5 percent of the total NASA budget. Considering its potential return to the U.S. economy through aeronautical product sales by the industry it serves, this is a high yield budget.

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[1] Testimony by R. F. Gamble, Group Vice Pres.—Controls, United Technologies Corp. before Senate Subcommittee on Science, Technology and Space, Mar. 10, 1981.

[2] Testimony by R. L. Foss, Chief Engineer, Lockheed Aircraft before House Subcommittee on Transportation, Aviation and Materials, Feb. 26, 1981.

[3] Journal, Vozdushny Transport, A. Markov, Chief of the Forecasting Section of the Soviet Ministry of Civil Aviations Scientific and Technical Diretorate (as quoted in Flight International, Feb. 13, 1982).

We firmly support the Administration's general economic recovery plans, including reduction of government spending. Within the guidelines of the Administration's plans it is appropriate to adjust priorities to best serve the nation's interest. Within these guidelines, therefore, we strongly urge preservation of the NASA Aeronautics budget, including programs for propulsion research and technology.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. Effects of the Economic Recovery Act on the U.S. aeronautics industry research and development.

Answer. ERTA provides that tax credits for R&D are available to the extent that profits are directed to increasing R&D expenditures. Historically, United Technologies has increased its R&D expenditures from year to year. For example, $736 million was expended in 1981, as compared to $660 million in 1980. However, given our industry's near-term funding requirements, it is unlikely that U.S. industry could commit funding for advanced proof-of-concept work in a timely manner. In this sense, the long range R&D tax credit from ERTA does not replace the long term exploratory work traditionally carried out by NASA.

However, the Economic Recovery Act of 1981 contains two beneficial features that will have an indirect effect on research and development in the U.S. aeronautics industry through revenues, profits, and cash flows produced by sales of aircraft, engines, and other aviation equipment to the U.S. domestic airlines. These two features are the Accelerated Cost Recovery System (ACRS) which permits faster depreciation write-off of new equipment, and the liberalized treatment of investment tax credits.

Question 2. What access do you have to DoD Programs as compared to NASA? Are there time differences in acquiring DoD related program data as opposed to NASA? If so, what are these differences?

Answer. DoD engine technology programs are generally specific mission oriented in nature, usually leading directly toward a product prototype. When such military programs are conducted by our Government Products Division the results are generally available to the Commercial Products Division. Information on competitor military technology programs is generally not made available by DoD except in rare circumstances where a technology transfer is deemed essential to a specific military requirement.

NASA technology programs, on the other hand, concentrate more on generic long term technology and the results of all NASA programs are published in interim and final reports. These are made available to all of industry and are of benefit to military as well as civil aviation. This tends to upgrade the overall technology base of the U.S. and reduce unnecessary duplication of competitive technology efforts. Unfortunately, the NASA reports are also made available to competing foreign civil and military aircraft industries through the National Technical Information Service. This vast technology give-away should be stopped.

Question 3. What percentage of your company's gross income is expended on your own R&D efforts?

Answer. Research and development expenditures for United Technologies Corporation amounted to $736 million in 1981 out of gross sales of $13.7 billion or 5.4%. For the Pratt & Whitney U.S. divisions the Research and Development expenditures amounted to $400 million or 8.8% of their gross sales.

Question 4. One funding option for NAS looks at a joint development program and recovery of capital costs. Could you please elaborate on your concerns about this approach?

Answer. NAS (Numerical Aerodynamic Simulator) offers promise over the long term for advancing computational fluid mechanics in the U.S. and increasing the competitiveness of U.S. industry. The benefits from this national resource could be similar to those enjoyed by the U.S. from its investment in other long-term NASA activities. Since the facility would be used by government agencies, academia, independent research institutes, and industry, it is impractical to consider funding of the project jointly by NASA and the potential users, because of the difficulty of obtaining consistent direction from so many sources.

To insure success of the NAS, it would seem most appropriate to assign funding, responsibility and direction for the facility to NASA and encourage it to seek advisory input from potential users. It is to be expected that some form of user's fees could be imposed to recover operational cost and allow for continuing upgrading of the facility.

Question 5. How important do you consider NASA's proposed program on the numerical aerodynamic simulator?

Answer. Over the long term, advances in computational fluid mechanics will be of great importance to the technical excellence of many segments of U.S. industry. Industry looks to NASA and its computational efforts for advanced computer code development, and for new computer codes which can be streamlined or simplified for industrial use. If NAS is to be built it will require a long term commitment as well as guidance for its development and use by an advisory group with personnel from both industry and universities.

NAS, in our opinion, will not be able to increase dramatically the productivity of the design process for aircraft engines. Simply stated, one of the purposes of NAS is to solve very complex problems in computational fluid mechanics that are not now practically solvable because of the numbers of variables involved and the long computation time required on present day computers. Our current design procedures are limited by technology levels and by the complexity of the geometry required to describe our components, not by computing speed. In addition, the initial computational advances arising from NAS, should it be implemented, probably will be applicable to exterior flows. Historically, it will take five to ten years beyond this point, on a case-by-case basis, to apply such techniques to the more complex situation of the internal aerodynamics of engines. Thus, dramatic increases in engine design productivity are not envisioned. In fact it is difficult to envision a situation where NAS would be used in engine design applications. NAS would require a completely new computer language for data input, and there would be scheduling problems related to its use. Finally, NAS is incompatible with man-in-the-loop (Interactive) design systems which are becoming standard throughout the aerospace industry.

Question 6. What might your position be to changes in the NASA enabling legislation which could permit the recovery of some facility R&D funds by NASA in user fees for these facilities? What pricing structure would you propose?

Answer. There should be enabling legislation allowing user fees to be converted to NASA R&T funds. However, procedures and practices should be standardized relative to program selection and pricing.

High risk, long term research and technology programs are within NASA's charter and are rightfully a NASA responsibility.

Question 7. What do you believe the proper balance should be between the NASA research and technology base programs and the systems technology programs?

Answer. The nature of the particular research and technology base concepts and their verification requirements should serve, on a case-by-case basis, for rational determination of the proper balance between R&T base programs and systems programs. This is consistent with the report of "NASA's Role In Aeronautics: A Workshop" conducted by the Aeronautics and Space Engineering Board" at Woods Hole, MA July 27–August 2, 1980.

NASA should pursue new, long-range, generic R&T base ideas which show promise of civil and/or military benefits for aircraft product requirements projected 10 to 20 years. The extent to which NASA should carry each program should be based upon reducing the risk to the point where industry will accept technology readiness of the concept for application to a product program. In the case of the military, the concept might be adopted earlier for a more specific demonstrator rig or mission-oriented prototype verification program. The nature of some concepts is such that technology readiness can be established by base R&T single technology discipline programs alone whereas many can only be established by verification in actual systems programs.

A group composed of NASA, military and industry representatives should review candidate programs periodically to ensure use of the most expeditious approach to verifying technology readiness of advanced concepts. This should make maximum use of existing NASA—or industry-owned aircraft, rig hardware, components, or existing engines for concept evaluation purposes with a minimum of new and unique hardware. It is usually unnecessary, or economically ineffetive for advanced concept verifications to be conducted in unique advanced systems hardware designs. This approach which fosters a joint sense of program ownership between NASA and industry and will tend to ensure that the technologies being pursued are relevant to future needs.

The degree of verification necesary also should be reviewed as the technology programs progress to ensure that NASA carries any program only to the point where the risk would be acceptable for industry to adopt the concept for a product development program. This approach would result in the maximum possible number of advanced technology concepts being evaluated with the available NASA funding.

Question 8. It's acknowledged that the number of foreign transport aircraft produced is being sold each year. What percentage of these aircraft contain U.S. parts and materials, i.e., powerplants, avionics, etc. Within each aircraft type what percentage of U.S. equipment is on that type?

Answer. All non-Soviet, foreign-produced widebody transports manufactured to date are powered by engines designed and developed in the U.S. This is attributable to the supperiority of engines designed and manufactured in the U.S. This was made possible in part by NASA's role in building a strong techology base in aeronautics.

By supporting proof-of-concept work, NASA has shown the way for industry to channel its development resources. One proof-of-concept example stimulated by NASA Lewis Research Center in the 1950s led to the technology that enabled compressors to accept a higher axial airflow velocity. That work on the transonic flow compressor became the basis of today's highly-efficient compressor designs. It made the fuel-efficient, high-bypass ratio turbofan engine possible. Similarly, NASA's support of the propfan concept, with its potential for even more fuel savings, could usher in the next significant innovation in aviation history.

Without adequate government support of long-term technology advancements, our industry's ability to continue to provide competitive commercial aircraft systems will be compromised severely.

Question 9. What do you see as needed for the future in the energy efficient engine program?

Answer. Some of the remaining Energy Efficient Engine program funding should be use to complete the establishment of technology readiness for promising advanced concepts. In the case of the Pratt & Whitney program, this should include further rig testing of the combustor and high pressure turbine components.

The remaining E^3 demonstrator funding should be applied to examining new, advanced technology concepts, such as lightweight unshrouded fan; rotor blading; improved efficiency turbine airfoils and improved high-temperature materials and thermal barrier coatings.

In addition, NASA should sponsor a study of a much more advanced engine which might enter production in the years 2000 to 2010, so as to identify promising long-term technology concepts for future R&T funding.

You should know that many of the concepts in the Pratt & Whitney E^3 program were so promising that their development is being continued for application in the PW2037 engine, which has been chosen to power Boeing's new 757 transport. This is an indication of the success of the E^3 program in identifying and accelerating the development of technologies to improve the energy efficiency of future engines.

Question 10. What NASA development do you recommend will bring the turboprop program to the point where your company will develop it for production?

Answer. The advanced high speed turboprop or propfan shows promise of the largest potential fuel savings (15 to 20 percent) of any signle future concept.

The advanced, highly swept blade propfan is a revolutionary concept when compared to advanced turbofan engines that would be available in the same time period. Therefore, technology verification of the propfan must be continued, with a great deal more systems substantiation before industry will begin a product development program. If the propfan concept is not brought to technology readiness in the U.S. by the mid 80's so that propfan aircraft could be introduced to commercial service by the early 90's, this market may be filled with foreign-built aircraft and engines.

For these reasons, an accelerated and enhanced program was recommended by industry to NASA in January 1981. Much up-front proof-of-concept work, now supported by NASA's Advanced Turboprop Program needs to be done before the U.S. private sector can undertake a new aircraft for production. The principal proof-of-concept items which must be demonstrated are: (1) cabin noise reduction, (2) propeller structural integrity and aeroelastic stability, (3) gearbox reliability, and (4) systems integration of the propeller, engine and aircraft. Given our industry's near-term funding requirements, it is unlikely that U.S. industry could commit funding for this proof-of-concept work in a timely manner. In addition, in order to utilize this technology, U.S. industry, at its own risk, will have to invest approximately 2 billion dollars of its own money to develop a product and sell it against foreign competition on the world market.

Senator CANNON. Thank you very much. Thank you, Mr. Chairman.

Senator **Schmitt**. I appreciate your taking over for me briefly there while I was away.

Our final statement will be from Mr. Ronald Neal.

STATEMENT OF RONALD D. NEAL, SENIOR VICE PRESIDENT, PROGRAM MANAGEMENT AND TECHNOLOGY, GATES LEARJET CORP.

Mr. **Neal**. Thank you, Mr. Chairman. I am Ronald D. Neal, senior vice president for program management and technology, Gates Learjet Corp.

Since I understand that my full statement will be made a matter of record, I will then proceed to provide you with some summary comments.

Senator **Schmitt**. Yes, that will happen.

Mr. **Neal**. Thank you. I should then like to briefly describe some of the more significant benefits that the NASA-industry relationship have provided Gates Learjet. I want to particularly underscore the trends of change now evolving within that relationship and their possible consequences.

The original Learjet was designed and developed almost 20 years ago by a group of less than 100 engineers. The company had no wind tunnels, limited computer facilities, and little other related equipment with which to do the development work necessary to produce a high-performance aircraft. Instead, we relied heavily on the basic technology that NACA and NASA had developed over decades of research. The results of this research were available through the extensive reports published by these Government agencies.

Let me illustrate. Learjet wings and tails employ modification of NACA airfoil sections. The airfoils that we used as a baseline were developed at NACA's Langley facilities in the last 1930's and early 1940's. Our wing flap design was developed directly from experimental work of NACA.

Learjets are the only business jets using the squeezed-in or area-ruled fuselage outline which gives it the so-called Coke bottle look. The resulting effect of this shape which was first reported by NASA is a substantial reduction in high-speed drag.

A very recent and highly visible example of the benefits afforded by working with NASA is the winglet appearing at the tip of each wing on the Learjet 28 and 29 models and the new Learjet 50 series aircraft. These upturned tips were also conceived by NASA. Gates Learjet, working closely with NASA, was the first manufacturer to adopt them for a production aircraft.

Winglets enhance the energy efficiency of our airplanes by reducing the aerodynamic drag. I might mention that while the basis concept originated at NASA, the tailoring of the actual design for our application was undertaken at Learjet expense, just as it should have been.

I would also interject that this is probably an excellent example of NASA validation and industry demonstration of a practical concept.

Some 14 years ago a Learjet airplane was tested in the NASA 40 by 80-foot, full-scale tunnel at Ames, thereby providing NASA and our entire industry with the first, and still the only, body of aerodynamic data based on tunnel tests of an actual business jet aircraft. The airplane used for the test was our second airplane and this airplane now hangs in the National Air and Space Museum.

More recently, we have worked cooperatively with NASA Ames in the development of the advanced wing sections for low drag at high speeds. Methods developed at NASA Ames have been used to visualize the airflow around wing sections in actual high-speed flight. The cooperative efforts of NASA and Ohio State University made possible the accumulation of wind tunnel data on these airfoil sections, and the comparison of test results with theory.

There is a trend and it is this: You will note that the design of the first Learjet certified for operation in 1964 drew heavily from an immense data bank developed by researchers whose work was accomplished as much as 25 years earlier. Over the years we have made an increasing use of more recent NASA research. Now our company has caught up with NASA. Today we are working cooperatively with NASA at the razoredge of the technologies that we need.

The historical path of basic research findings from NASA to the military and then to the civil industry have been shortened by many years. We are now at the point where we will work with NASA on a day-to-day basis in certain specialized areas. What this means is that aircraft manufacturers of our size whose potential for basic and applied research, though improved, is still limited and could find our progress passed by the progress of NASA.

Our future success in world markets, which we have dominated until now, will quite literally and directly depend upon the success of NASA in performing the basic advanced aeronautical research which the agency and the industry can and should do together.

Your committee requested comments on the aeronautical technology programs that would benefit our type of product line. The general answer to this question is that we would encourage support of any program that pursues energy efficient concepts in the area of aerodynamics, propulsion and materials. We do not believe that NASA's role is to develop actual aircraft hardware, but rather the agency should concentrate on advanced concepts that can be applied by industry to its product.

You also asked for our assessment of aviation technology and marketing developments abroad and their effects on the national economy and the economic health of the Nation's aeronautical industry.

As a partial answer to that question, permit me to quote Mr. Harry B. Combs, president of Gates Learjet. In testimony before a joint Senate-House committee in Wichita, Kans., last August, Mr. Combs stated:

> The current true state of our aeronautical capabilities compared to foreign competition continues to be a subject of considerable debate. But on one very fundamental point most authorities are in total agreement. In recent years U.S. research and development efforts have lagged behind other nations.

A very positive and extensive contribution of research and development to economic growth and productivity already has been well documented by a number of government and industry studies. Most of these studies conclude that unless present trends are reversed, the United States will be less of a factor in world markets.

Not too long ago there were six U.S. manufacturers building business jets, with the foreign competition coming from the aircraft industries of three countries—France, Germany, and England. Today there are only three U.S. manufacturers building business jets, and these three companies now face foreign competition from five other countries—Canada, England, France, Israel, and Japan. These foreign manufacturers are either owned or heavily subsidized by their respective governments.

It is very clear that the Japanese aviation industry has a definite objective of moving into our markets. In order to survive as a worldwide business jet market, U.S. manufacturers must provide the best technical product. It must be a quality product and it must be offered at a competitive price.

Clearly the Government cannot and should not solve all of the problems involved in the sale of commercial products. However, in the area of technology the Government can help by continued support of the national commitment to basic research, such as can be found in NASA's aeronautical programs.

The real question before us today is simply this: Whose airplane will be in our future—those designed and built in the United States or those produced outside U.S. borders. Part of this answer and part of the answer to this question rests with the level of technology that we can incorporate into our products.

Thank you very much.

[The statement follows:]

STATEMENT OF RONALD D. NEAL, SR., VICE PRESIDENT, PROGRAM MANAGEMENT AND TECHNOLOGY, GATES LEARJET CORP.

I am Ronald D. Neal, senior vice president for program management and technology of Gates Learjet Corporation. Gates Learjet is an organization engaged in the design, development, manufacture and marketing of high performance business jet airplanes for markets in the United States and abroad About 25 percent of all business jet aircraft in the world are Learjets.

Our company also operates a network of aviation sales and service facilities, and a wholly-owned subsidiary devoted to the development, production and marketing of airborne electronic systems for a wide range of advanced civil and military aircraft.

Members of this committee are well informed on the activities of the National Aeronautics and Space Administration—and on the working relationship between NASA and the U.S. aircraft industry. You are currently reviewing the program and budget request submitted by NASA for fiscal year 1983, and you are familiar with the declining percentages of those plans which have been projected for aeronautical research and technology. There is no need for me to restate them here.

Instead, I should like to briefly describe some of the more significant benefits this ongoing NASA-industry relationship have provided Gates Learjet. I want to particularly underscore the trends of change now evolving within that relationship—and their possible consequences.

The Learjet product is known worldwide. In fact, the name Learjet has become an almost generic name for business jets, such as Kleenex has for facial tissue and Xerox for duplicating machines. What is not so well known, however, is the small beginning of our company and the extent to which it has depended—and still depends—upon technologies developed outside, most notably by NASA and its predecessor, the old National Advisory Committee for Aeronautics, or NACA.

The original Learjet was designed and developed almost 20 years ago by a group of less than 100 engineers. The company had no wind tunnels, limited computer facilities, and little other related equipment with which to do the development work necessary to produce a high-performance airplane. Instead, we relied heavily on the basic technology that NACA/NASA had developed during decades of research. The results of all this research are available through the extensive reports published by these government agencies. Let me illustrate:

Learjet wings and tails employ modifications of so-called laminer-flow wing sections. The airfoils we used as basepoints were developed at NACA's Langley Field facilities in the late thirties and early forties by Eastman Jacobs, Ira Abbott, Albert E. von Doenhoff, Julien Allen and their colleagues. The landing flap design proceeded from the experimental work of Jones F. Cahill at NACA.

Learjets are the only business jets using the squeezed-in (area rule) fuselage outline which gives it the so-called "coke-bottle" look. The resulting effect of this shape, which was first reported by Richard Whitcomb and his associates at NASA, is a substantial reduction in high-speed drag. Most high-performance military aircraft designs also feature this type of fuselage configuration.

A very recent and highly visible example of the benefits afforded by working with NASA is the winglet appearing at the tip of each wing on the Learjet 28/29 models and the new Learjet Longhorn 50 series aircraft. These upturned tips were also conceived by Mr. Whitcomb of NASA. Gates Learjet, working closely with NASA, was the first manufacturer to adapt them for production aircraft.

Since then winglets have been adopted by other business jet manufacturers. And they have been developed and tested for the Boeing KC-135 and the McDonnell Douglas DC-10.

Winglets enhance the energy-efficiency of our airplanes by reducing the aerodynamic drag by as much as 8 percent. I might mention that while the basic concept originated at NASA, the tailoring of the actual design for our application was undertaken at Learjet expense, just as it should have been.

Fourteen years ago a Learjet airplane was tested in NASA's 40-by-80-foot, full-scale wind tunnel at Ames, thereby providing NASA and our entire industry with the first—and still the only—body of aerodynamic data based on tunnel tests of an actual business jet airplane. The airplane used for the NASA tests was our second Learjet flying prototype. It now hangs in the National Air and Space Museum.

More recently, Learjet has worked cooperatively with Raymond Hicks and his associates at NASA Ames in the development of advance wing sections with very low drag at high speeds. Methods developed at NASA were used to help visualize the airflow around these sections in actual high-speed flight. The cooperative efforts of NASA and Ohio State University made possible the accumulation of wind tunnel data on these sections—and the comparison of test results with theory. This service is available to the Nation's entire aircraft industry.

For our investigations of advanced aircraft structures, Gates Learjet uses the NASA-developed, highly sophisticated computational technique known as NASTRAN. Initiated in the late 1960's, NASA's work in expanding the capabilities of NASTRAN is still in progress. NASTRAN technology is now being applied at our company in the ananlysis of composite material structures.

Learjet airplanes are certificated for operation in known icing environments. A major contributor to the background information in this area is NASA's Lewis Research Laboratory at Cleveland.

All Learjet airplanes have mechanical, unpowered flight control systems. The shaping of the control surfaces to minimize the forces the pilot has to exert was made possible by work performed by NACA in the 1940's, and reported by Francis Rogallo in what is still probably the world's most complete collection of test data in this particular area.

The understanding of the detailed behavior of airplanes in controlled flight, which enabled the proportions of the original Learjet to be defined, using fairly simple criteria, came from the work of NACA investigators Charles Zimmerman, Robert T. Jones, Doris Cohen and others, which they performed in the early and mid-1940's.

Now there is a trend here, and it is this: You will have noted that the design of the first Learjet, certificated in 1964, drew heavily from an immense data bank provided by NACA/NASA researchers, whose work was accomplished as much as 25 years earlier.

Over the years, we have made increasing use of more recent NASA research. Now, our company has caught up with NASA. Today we are working cooperatively with NASA at the razor edge of the technologies we need. The historic path of basic research findings, from NACA or NASA to the military and then to the civil aircraft industry, has been shortened by many years. We are now at the point where we work with NASA on a day-by-day basis in certain specialized areas.

What this means is that airplane manufacturers of our size, whose potential for basic and applied research, though improved, is still limited, will find their progress paced by the progress of NASA. Our future success in world markets, which we have dominated until now, will quite literally and directly depend upon the success of NASA in performing the basic advanced aeronautical research which the agency and the industry can and should do together.

Your Committee has also requested comments on the aeronautical technology programs that would benefit our type of product line. The general answer to this question is that we would encourage support of any program that pursues energy-efficient concepts in the areas of aerodynamics, propulsion, and materials. We do not believe that NASA's role is to develop actual aircraft hardware, but rather the agency should concentrate on advanced concepts that can be applied by industry to its products.

Your letter also asked for our "assessment of aviation technology and marketing developments abroad, and their effects on the national economy and the economic health of the Nation's aeronautical industry."

As a partial answer to this question, permit me to quote Mr. Harry B. Combs, president of Gates Learjet. In testimony before a joint Senate-House committee in Wichita, Kansas, last August, Mr. Combs stated:

"The current true state of our aeronautical capabilities compared to foreign competition continues to be a subject of considerable debate. But on one very fundamental point most authorities are in total agreement: In recent years U.S. research and development efforts have lagged behind other nations."

The very positive and extensive contribution of research and development to economic growth and productivity already has been well documented by a number of government and industry studies. Most of these studies conclude that unless present trends are reversed, the U.S. will be less of a factor in world markets. And declining economic power could result in declining political influence abroad as well.

Not too long ago there were six U.S. manufacturers building business jets, with the foreign competition coming from the aircraft industries of three countries—France, Germany and England. Today, there are only three U.S. manufacturers building business jets, and these three companies now face foreign competition from five other countries—Canada, England, France, Israel and Japan. And these foreign manufacturers are either owned or heavily subsidized by their respective governments.

In order to survive in the worldwide business jet market, U.S. manufacturers must provide the best technical product; it must be a quality product, and it must be offered at a competitive price. Clearly, the government cannot and should not solve all of the problems involved in the sale of commercial products. However, in the area of technology the government can help by continued support of a national commitment to basic research, such as can be found in NASA's aeronautical programs.

One of aviation's greatest assets is the intellectual and creative engineering capacity embodied in NASA. Yet because R and D has fallen victim of budget restrictions in our present economic environment, what could be and should be a national asset has become somewhat of a liability.

NASA can and should expand its aeronautical R and D. Congress should see to it by appropriate funding and validation. Moreover, the President should support accelerated research and development as a national policy. Then and only then can NASA's aeronautical endeavors be called an asset, which Webster defines as "anything owned that has exchange value; a valuable or desirable thing to have."

Many years ago, during another slowdown in NASA's aeronautical activity, a friend of mine was bemoaning the situation with a representative of the Federal government. The government official said, "We had better take note of the fact that when people want to get somewhere fast, they go in airplanes. Ten years from now they will still go in airplanes."

This statement is even more significant now than ever. But the real question before us today is simply this: Whose airplanes will be in our future—those designed and built in the United States, or those produced somewhere outside America's borders?

Thank you.

Senator SCHMITT. Thank you, sir. Mr. Neal, why isn't there a more aggressive commuter aircraft manufacturing industry in the United States?

Mr. NEAL. Well, we, for our part, have looked at that segment and it is a rather broad segment that can run all the way from very small airplanes, as you know, to fairly large ones. I think one of the problems that we face when we have looked at it is the financial capability of the commuter industry to afford the type of equipment that we would be in.

The other area, in my opinion, as the influence is if you are not in a given market, it is a lot easier to go after it. So if you have no business and you are targeting what you are going to go into, the commuter market is a potential and that is why we say some of the foreign interests. If you are already in there you have to be careful that you do not compete with yourself and your product line, and you have to be certain that the economic risk justifies it.

As I think you have heard, I think in many cases some of the foreign competition view it not only from technology standpoints but also from an employment standpoint.

Senator SCHMITT. Do any of the other panelists care to comment on the commuter question? You would agree with that assessment. We have a lot of head nods.

Mr. Cleveland, in your statement you asked the question: Would the public accept and fly on a brand-new propfan commercial transport at Mach .8 if the same speed aircraft were offered to them alternatively without propellers but with higher fares?

Could I ask each member of the panel to answer that question?

Mr. CLEVELAND. I would be fascinated to hear it myself.

Senator SCHMITT. Mr. Donohue?

Mr. DONOHUE. I will pass first.

Senator SCHMITT. OK. Who wants to try it first?

Mr. PARMET. I will try it.

Senator SCHMITT. All right, Mr. Parmet. Since you do represent the operational types, what do you think?

Mr. PARMET. I am not a marketing man. I think, if in fact you could operate such a vehicle much more cheaply than you could a straight jet, for instance, or a fanjet, the answer is obviously going to be yes.

The traveling public, one of the principal things it looks for is low cost, and that is true today. You can make the same comparison. A low-cost operator today with the same equipment, if he can offer lower fares, is going to draw a bigger marketplace to him, provided he can stay in existence at that lower fare.

Therefore, I think that if you had a Mach .8 vehicle, turboprop-powered, that was good and reliable and could be maintained at costs that are comparable to other technical equipment, then yes. It gives the operator a greater margin to generate a profit and he can offer that either through reduced fares or greater reliability. But basically reduced fares, I think, would draw people to such an airplane if it is equivalent.

Now if it is noisy and rattles the fuselage and shakes up everybody, that is another thing, but that is not equivalency. I hope I have answered it as best I can.

Senator SCHMITT. Yes. Anybody else?

STATEMENT OF THOMAS F. DONOHUE, GENERAL MANAGER, ADVANCED ENGINEERING AND TECHNOLOGY PROGRAMS DEPARTMENT, AIRCRAFT ENGINE BUSINESS GROUP, GENERAL ELECTRIC CO.

Mr. DONOHUE. My apologies for not answering the question first. Unfortunately, I misheard your word fares to failures and that suddenly made it a rather different question.

I do not think there is any reason to expect people to be reticent at all to fly on a propfan type of vehicle. We do have to provide the assurances that the internal comfort level and the noise aspect is comparable. Perhaps we can envision that it is essentially the same as the air fuselage-mounted engines are today, which really are fairly noisy in the back of the airplane.

If that comes to pass, I think that there should be no reluctance on the part of the general public to climb aboard an airplane with propellers, especially if the fare was lower.

[The statement follows:]

STATEMENT OF THOMAS F. DONOHUE, GENERAL MANAGER, ADVANCED ENGINEERING AND TECHNOLOGY PROGRAMS DEPARTMENT, AIRCRAFT ENGINE BUSINESS GROUP, GENERAL ELECTRIC CO.

Mr. Chairman and members of the subcommittee, I am Thomas F. Donohue, General Manager of Advanced Engineering and Technology Programs Department of the Aircraft Engine Business Group of the General Electric Company. As a member of the aeronautical technology community and having familiarity with both Government and industry efforts in aeronautics research and technology, I am appreciative of this opportunity to discuss the need for maintaining a strong activity in this area.

For many years the U.S. has been dominant in world aviation by building on the research and technology developments generated under both the military and NASA sponsorship. There is no question but that the aeronautics industry is large and relatively strong, but also, it is equally unquestionable that our leadership position is eroding away. We like to look at the favorable balance-of-payments provided by our exporting avitation products. As much as we enjoy our foreign markets, these sales do permit the evaluation of the status of our technology and enhance their technology awareness. Foreign governments and industry have invested in modern facilities, extensive research and technology efforts and in actual product development to fill world-wide needs. It appears that the only approach to maintaining our current position is to continue to reinvest in technology.

New airplanes are huge investments requiring many long years of successful sales before break-even occurs and a positive return on the investment reached. New engines can cost in the order of a billion dollars to design, develop and introduce once the basic technology is available. In addition, when compared to aircraft, the development time is longer and an proportionately greater amount of continuing development following service introduction is required. The long time cycle for major developments strongly influences business strategy by industry. We operate in a rather broad and volatile market while having a 15-year total time span between early technology development and break-even for even a highly successful program. Thus, a fundamental business strategy is to focus resources to the most stable and predictable market which generally is nearer term. ("Nearer term" can easily be 7 years). As a consequence, it becomes difficult for an engine manufacturer to sustain a full-scope Research and Technology (R&T) program. We, and others, rely on Government agencies to spur advancements and either directly participate as a contractor, or at least have access to Government-sponsored activity throughout industry, the military labs and NASA Centers.

In my view, NASA has an important role in supplying "seed money"—but not the supplier of "venture capital"—in the wide ranging areas of aeronautics technology. NASA has a most important opportunity to foster new and interesting ideas—innovations—within the entire aeronautics community. Some should be self-generated, some should be encouraged by supporting high risk/high payoff programs with contractors. The NASA aero industry partnership, unique among U.S. Government and industry relationships, is necessary to continuing the flow of technological advancement in order to assure U.S. competitiveness. This partnership is based on the mutual interest in doing the job better and mutual technical respect.

Propulsion technology is a very significant driver in the generation of improved aircraft. The great improvement in fuel consumption of our more recent commercial airliners has been the result of both airplane and engine technology advancement. The amount of fuel required to fly a passenger from San Francisco to New York on the newest aircraft in 1985 will be about one-half that consumed in the early sixties. Propulsion will have provided the greatest percentage of this rather remarkable achievement. The world's airlines buy the most attractive aircraft offered by the manufacturers, principally those having the lowest overall operating cost. The best aircraft can be produced only by those having the capability to apply the best available technology.

On the military side, we see a surge of interest in providing improved fighter aircraft to counter military threats projected for the 1990's. Concepts are being formulated which would not be economically feasible without technology advancements in both the air vehicle and propulsion. Studies show that propulsion will provide the greatest percentage of potential system improvement as constrained by airplane size (hence, cost) considerations. Ideas stimulated by NASA propulsion systems programs may contribute heavily to the engines needed.

Substantial payoff for both civil and military systems can be foreseen through the development and application of advanced technology. While my remarks are directed toward projections of technology development needs for the civil area, I would like to point out that the similar military airlift and tanker technology needs are met by the civil side of industry. Some of the key programs sponsored by NASA which have been jeopardized or lost by budget actions include:

Subsonic turbofan technology developments utilizing the resources generated in the Energy Efficient Engine program. It is foreseeable to further reduce the fuel consumption of E^3 by an additional 10 percent through aerodynamic refinement of the system and adjustments to the thermodynamic cycle.

Advanced turboprop technology can offer reductions in fuel consumption of approximately 12 percent beyond the potential offered by the most advanced turbofan. Many areas of turboprop technology and advanced propeller design need exploration. Flight test of propeller configurations, such as the swept blade propfan, is needed to provide confidence in the basic concepts prior to development.

Investigation into the serviceability aspects of large primary structures manufactured from composite materials is of great interest to the airplane industry. The engine industry has a similar interest in determining the suitability of this type of material for primary structures in the lower temperature areas of the engine. The environment such structures might see would be far more severe than that seen by aircraft structures.

As you are aware, the engine industry is a large consumer of "strategic materials" which are expensive and difficult to process. We find that the key to affordable technological improvements lies in innovative materials and process development. We are disappointed that much of the materials effort applicable to turbine engines has been eliminated.

Industry is highly dependent on advanced analytical methodology generated by NASA. Continued expansion of computer code and computational capability in the area of turbomachinery fluid dynamics is necessary. Practical demonstration of component designs based on advanced computer techniques is needed to affirm their validity.

The foreseeable advancements in aeronautics, both civil and military, which can result from continuous renewal of our technology base appear to be compatible with U.S. public interests. Disengagement from any of the fundamental areas of aeronautical technology development would prove damaging to the aviation industry. A diminishment in technological growth in propulsion would both slow and decrease improvements in airplanes. As the potential for these improvements exist, someone, someplace will develop it. Foreign competition, spurred by direct support of both technology and product development, will continue to intensify.

We cannot stop it, but we can learn from the experience of other industries such as steel, automotive, and even high technology electronics. Seemingly, the best approach to deflecting serious inroads is to keep renewing our technology base and maintain a measurable technology lead.

[The following information was subsequently received for the record:]

QUESTIONS OF THE COMMITTEE AND THE ANSWERS THERETO

Question 1. What are the effects or what do you expect the effects to be of the Economic Recovery Act on the U.S. aeronautics industry research and development?

Answer. There are many diverse factors that impact the overall economic outlook in general. The aeronautics industry segment of the economy responds to these factors as appropriate, including the allocation of resources for research ad development. The ERA, particularly the Accelerated Cost Recovery System (depreciation) and the Research and Experimentation Tax Credit provisions, will prove positive in encouraging decisions to increase R&D expenditures. However, the overall perspective of the Aircraft Engine Business Group is that too little time has past since the enactment of this legislation to allow for a reasonably accurate assessment of the expected effects—either in terms of quantity or timing.

Question 2. What access do you have to DOD programs as compared to NASA? Are there time differences in acquiring DOD related program data as opposed to NASA? If so, what are these differences?

Answer. With respect to access to program data of DOD compared to NASA, our observation is that no significant difference in access exists. Recognizing that "access" may be viewed as formal and informal, the availability of documentation through DDC (Defense Documentation Center) and the NASA counterpart, STINFO (Scientific and Technical Information) appears efficient, thorough, and are important sources of historical data. In the case of the more informal subjects, planning data, technical data awaiting publication, etc., both agencies are helpful and cooperative where a need exists. Occasionally, the establishment of a need-to-know in some sensitive areas adds time; but rarely, has this been excessive. For the record, we think it important to point out that both agencies are and have been particularly prudent in those areas where proprietary data warrants special handling.

As a general view, therefore, we do not perceive any significant difference in access to program data of the DOD as compared to NASA.

Question 3. What percentage of your company's gross income is expended on your own R&D efforts?

Answer. During the three year period 1979 through 1981, General Electric Company expended 27 percent of gross income on Company-funded R&D in 1979 and 31 percent in 1980 and in 1981 (data source 1981 annual report). The level of Research and Development expediture by the Aircraft Engine Business Group is held proprietary. However, the percentage of AEBG gross income expended for aviation related research and product development was far greater than the overall Company percentage.

Question 4. Last year the committee was concerned about the overall costs for the NAS. Consequently, the committee asked NASA for a report on the description of the program, the status and to look at funding options. One option explored looks at a joint development program and recovery of capital costs. Could you please elaborate on your concerns about these approaches?

Answer. The Numerical Aeronautical Simulator (NAS) represents a large investment which can prove of great value to the aeronautics industry and to the nation as a whole. Yet, it is to be a facility, utilized much like existing wind tunnels and altitude test chambers. We have found no reasonable alternative to the direct Government establishment of a new national resource.

Our principal concern over alternative funding approaches for the NAS is the scarcity of Research and Technology funding now and for the foreseeable future. We view the funding currently available to us as insufficient to support the desired (and entirely feasible) rate of technology development.

Beyond that, there are a number of operational and philosophical issues that we feel are important. For one thing, anything that disturbs the healthy partnership between NASA and industry must be viewed with concern. For another, this would establish a precedent which could result in future conflicts over the availability and usage of this facility and the basis upon which individual contibutions are determined. Finally, such funding would certainly reduce the valuable independence of NASA in the field of aeronautics and jeopardize its special relationship with the aerospace industry.

A key to the success of NASA has been their ability to work within a framework of broad-baed industry cooperation while retaining operational independence. Briefly, the ideas to be pursued are selected on the basis of their merit and value to the aerospace community and nation as a whole. We feel that it should remain this way.

Question 5. How important do you consider NASA's proposed program on the numerical aerodynamic simulator?

Answer. We consider the NAS to be very important to the continuing technological superiority of our nation and support its development, particularly in view of the growing competition from the aerospace community abroad. The NAS is a proper and necessary step in the exploitation of the computer and computational methodologies.

We anticipate that the impact of the NAS during the next decade will primarily be upon research, and in particular upon improving our understanding of and ability to predict the behavior of complex physical processes. Nevertheless, this is an essetial step in the eventual development of design tools for routine industry use. Since the results of these calculations are no better than the phenomenological models they employ, we strongly recommend that the investment in the NAS should be accompanied by an equally dedicated experimental effort to generate models whose accuracy is a match for the computational power of the NAS.

Please note that the NAS is currently being scrutinized by the National Research Council Computational Aerodynamic Simulation Technology Development Committee, which is jointly funded by NASA and the Air Force.

Question 6. What might your position be to changes in the NASA enabling legislation which would permit the recovery of some facility R&D funds by NASA in their user fees for these facilities? What pricing structure would you propose?

Answer. We do not advocate a change in the manner in which NASA facilities are used by industry. Programs receiving NASA sponsorship are provided access to and the operation of key facilities without fee. When a company feels that the need for preserving data rights is of great importance it pays for direct operating cost; i.e., manpower, power consumed, etc.

Expanding the application of user fees modeled along current lines would deter the use of these facilities for the exploration of advanced ideas—just the opposite of what is needed to assure technological growth. Further, only the largest and most powerful companies could afford substantial efforts to the detriment of broad-based competition within the entire industry. Establishing a fee structure to permit recovery of total cost would prove prohibitive for usage by industry in general.

Question 7. What do you believe the proper balance should be between the NASA research and technology base programs and the systems technology programs?

Answer. Systems technology programs provide the practical demonstration of technology elements in an environment consistent with their intended use. In general, they provide more impetus to product development than do R&T Base programs. We believe the Systems Technology programs to be a most significant portion of any R&T activity. An appropriate funding relation would be one dollar for Systems programs for every two dollars in R&T Base.

It's obvious that FY '82 and '83 NASA Aeronautics R&D budgets have shortchanged systems activities. Decline in Systems Technology programs slows the pace of technology development in critical and readily identifiable areas.

Question 8. It's acknowledged that an increasing number of foreign transport aircraft is being produced and sold each year. What percentage of these aircraft contain U.S. parts and materials; i.e., power plants, avionics, etc. Within each aircraft type what percentage of U.S. equipment is on that type?

Answer. The principal foreign transports being sold throughout the world are the Airbus A300 and A310 wide body airplanes. Both of these airplanes contain substantial U.S. parts and materials, including such components as engines and nacelles, air-conditioning equipment, communication and navigation equipment, electrical power, fire detection, instruments and pneumatics. It is estimated that approximately one-third of the initial purchase price of these airplanes is the value of the U.S content. When spare parts consumption is considered and allocated over the useful life of the airplanes, the U.S. content increases to approximately 45 percent.

The remaining foreign aircraft are in the smaller categories, aimed at commuter, local service and business operators. Based on information available to us the U.S content of these airplanes ranges from 5 percent to 10 percent if they contain only U.S. avionics equipment to 50 percent for cooperative programs such as the SAAB/Fairchild with U.S. engines. The approximate percentage U.S. content for a number of the airplanes in this category is shown below:

Approximate U.S. content

	Percent
CN 235—CASA/Nurtanio	35–40
SF 340—SAAB/Fairchild	50
Bandeirante 110—Embraer	30–35
Brasilia 120—Embraer	35–40

	Percent
BAe 146—British Aerospace	40
CL 600 Challenger—Canadair	35–40

Question 9. Would you please elaborate on your "disappointment that of the materials effort applicable to turbine engines has been eliminated." Please include in your reply financial and operational consequences as well as strategic.

Answer. The materials effort mentioned was NASA's Materials for Advanced Turbine Engine (MATE) Continuation program, planned as a new start in 1981 but cancelled by NASA prior to any contractual awards. General Electric, being a contractor in NASA's ongoing MATE program, proposed a total of three technologies for incorporation into the new program. These three technologies—"Stable Oxide Ceramic Turbine Shroud System", "Thermal Barrier Coatings for Turbine Blades and Vanes", and "PMR 15 Composite Engine Structures"—offer significant potential benefits to the commercial and general aviation industry. General Electric was anticipating being awarded a MATE contract for at least one of these proposed technologies.

The MATE concept is considered by General Electric to be an excellent approach to provide sufficient support to accelerate the effort needed to scale-up the development of a promising materials technology from laboratory feasibility through factory engine testing. This time period in a material development cycle consists of high risk that cannot adequately justify major investment of company resources. The need for a MATE program is even more significant when considering that it now takes longer between feasibility and first engine test and that the cost to get to the first engine test is a higher percentage of the overall development cost. The overall development cost is also increasing significantly, even beyond inflation factors, due primarily to the necessity to use more complex materials systems that require additional development activities.

General Electric's three proposed technologies are generically applicable to many of its planned engines in the 1985–1990 time frame and offer significant benefits. A benefit analysis, conducted during MATE proposal formulation, indicated that incorporation of these technologies into a 1990 fleet size of 100 aircraft each of CF6–80 powered 767's and 747's would result in a savings of $51M in fuel costs in that year alone. Other significant savings were also projected for different applications of these technologies. These overall projected benefits can provide an effective contribution towards meeting the intense demands associated with increasing foreign competition in the marketplace.

The development of each of these technologies continues at General Electric, but at a much smaller funding level than that anticipated if a MATE contract were awarded. No large Government programs have been awarded or are planned in the near future in each of these promising technological areas; therefore, the potential significant benefits will not be realized in as timely a manner as originally anticipated.

Question 10. Has the energy efficient engine program progressed to the point where your company has or can incorporate any of the technology developed to date from the program?

Answer. The Energy Efficient Engine Program is at a critical point in the demonstration of key, fuel saving technology features. The aggressive goals of the E^3 Program stimulated the development of relatively high risk, yet, realistic technology features, and challenged us to be more aggressive in the demonstration of fuel saving technology. We responded to this challenge and the program continues to be an outstanding success as we move into the fifth year of the program. All the major components have met or exceeded all design goals in their initial tests. We are extremely encouraged by these early results and are currently assembling the Core Engine to begin the evaluation of these technology features in a full engine environment.

Based upon the success of the component tests, we have identified key technology advancements which are of direct interest for new product development. Specific examples include the following:

The highly efficient fan configuration which is structurally enhanced beyond current production designs.

The high pressure turbine aerodynamic design which is significantly better performing than production.

The compressor blade/vane aerodynamic shaping which demonstrated improved efficiency.

In addition, the E^3 Program has provided an opportunity for the initial demonstration of ceramic shrouds in the high pressure turbine yielding performance gains through the reduction in cooling air. Also, thermal barrier coatings and an advanced high temperature alloy, AF115, have completed their initial engine demonstration in the E^3 Program. It should be noted that the E^3 Program provides for the demonstration of selected technologies in an engine environment whereas the effort contemplated under the MATE Program (referred to in the Question 8 response) would have provided extensive material characteristics and physical property information. The E^3 low pressure turbine development has been an important part of the overall General Electric effort in the evolution of high performance, low noise turbines and has provided an opportunity to explore the behavior of this new family of turbines at high altitude conditions. Electronic controls technology is further enhanced by the E^3 work, enabling the introduction of additional fuel saving concepts.

We are now actively engaged in studying the application of these features in a product engine in a thrust class 50 percent larger than that of the E^3 which is expected to be available for airline service in the 1986–87 time period. The E^3 Program is a driving force in accelerating the introduction of fuel saving concepts into airline service. Continued support of similar Systems Technology programs will be needed in the future to sustain this favorable trend.

Question 11. Has the turboprop program progressed to the point where your company can incorporate any of the technology to date from the program? What NASA development do you recommend which will bring the turboprop program to the point where your company will develop it for production?

Answer. The NASA turboprop program has served to refocus the industry on the potential fuel savings of turboprops and has shown an avenue of technology development toward smaller propeller diameter and higher flight Mach number, but it has not progressed to the point where propfan can be committed to full scale development with acceptable risk.

A flight demonstration program is essential to reducing aeromechanical risk, and must be conducted with 9-foot minimum diameter to allow representative composite blade layups to be employed. Also, work on acoustics and on propeller/aircraft drag interaction must be extended to assure that cabin noise levels will be acceptable and that the potential fuel savings will be realized in ensuring full scale development.

We also believe that NASA's traditional role as a source of R&D support for domestic engine and aircraft manufacturers for the civil market must be extended to turboprops to assure continued U.S. technological supremacy in aeronautics. Major initiatives in counter-rotating propellers, in lightweight gear reduction systems, and in dedicated turboprop cores offer high payoff in reduced fuel burn and DOC and must be undertaken before our foreign competitors invest in this promising technology and achieve superiority in civil and military applications.

Senator SCHMITT. Anyone have any contrary opinion? Mr. Withington.

STATEMENT OF H. W. WITHINGTON, VICE PRESIDENT FOR ENGINEERING, BOEING COMMERCIAL AIRPLANE CO.

Mr. WITHINGTON. No. I think it is pretty obvious that, all things being equal and the fares are less, the traveling public will certainly accept it. In our business 15 or 20 percent is a very large number.

[The statement follows:]

STATEMENT OF MR. H. W. (BOB) WITHINGTON, VICE PRESIDENT, ENGINEERING, BOEING COMMERCIAL AIRPLANE CO.

Mr. Chairman and members of the committee, my name is Bob Withington, Vice President Engineering of the Boeing Commercial Airplane Company. We appreciate the opportunity to respond to the points raised in your committee request for our testimony regarding the fiscal year 1983 NASA Aeronautical program.

We have had the privilege of working with the NASA since it was originally formed as the NACA organization. Results of their work and cooperation, combined with our in-house research has provided a base for consistent introduction of technology advancements into our product line. We now have the new Models 757 and 767 in the certification flight test process. The NASA participated in significant portions of the research leading to the development of propulsion, structural, flight deck, avionics and aerodynamic advancements in those models. The two models are now offered to the world market in an atmosphere of increasing competition from abroad.

The foreign competition is very real and a significant challenge to this country. At stake are the direct employment of nearly one million U.S. citizens, indirect influence on other segments of our economy and what has been a major contributor to our balance of trade. With a high level buildup in technology and production capability as well as attractive financing privileges—due to cooperative participation by their governments—the foreign competition now enjoys some 30 percent of the current market in contrast to 6 percent 10 years ago. As you may know, the Mitterrand government has recently launched a national program to increase its already sizable technology capabilities.

We believe the NASA can and should play an active role in meeting the challenge. In that respect, we are vitally concerned about the implications of the fiscal year 1983 program as now defined. We were acquainted with previous NASA planning directed toward additional technology advancements including composite structure, active controls, advanced flight deck and systems, laminar flow control and more efficient turborfan and turborprop propulsion. All offer significant potential. The budget consistent with that planning was nearly 50 percent greater than that made available for fiscal year 1982 and now being proposed for fiscal year 1983. Where those plans would have involved my company, the NASA participation would not have covered all cost by any means. However, when combined with the resources we could commit, the necessary research could have been conducted at an efficient pace.

We were very disappointed to find the fiscal year 1982 budget reduced from those previous plans to a level resulting in the phase-out of those existing programs. Further, we find the fiscal year 1983 budget is based on elimination of the type of research that could help bring those technologies to a state-of-readiness so that industry could commit the much greater resources required for their implementation.

The potential offered by these technology advancements is no secret. There is reasonable evidence that our foreign competition—again with the cooperative support of their respective governments—are aggressively pursuing that potential. In the past my company has committed a significant portion of our earnings to technology advancement research. For many years up to 1980 the internal funding that we were able to commit to technology advancement was approximately matched by funds derived from parallel government contracts. Results of that contracted work are, of course, immediately available to all U.S. industry. Our funding ability has remained nearly level in constant dollars since 1980 and we hope for that to continue. Since 1980, government contract funding has decreased substantially. We could well be limited to our own resources before too long, particularly if the proposed fiscal year 1983 program is adopted. Whether that will be adequate—in the absence of NASA participation—only the future can answer. Needless to say, a contest pitting the resources of a single company against those of aggressive foreign governments, presents a formidable challenge to that company. It is clear, all other factors being equal, the foreign and domestic markets will select their needed equipment from those products that are superior at any given time, regardless of the source. The degree of technology advancement will largely determine future product superiority. If of foreign make, the employment and economy of this country will suffer.

Our analysis indicates a continuing world market can be expected. This will be due to a reasonable long term traffic growth, an aging fleet requiring replacement and the need for more fuel efficient transports. The presence, or lack of an effective NASA aeronautical program could well be important to the ability of our industry to offer superior products to the demands of that market. We know that even with the extent of NASA and other government organization participation to date, we have lost significant ground. That history indicates removal of the cooperative participation would be counterproductive. We strongly recommend restoration of the budget needed to support the NASA progam as previously planned.

With your indulgence, I would like to cover one more point. This country is moving toward a much needed competitive military posture including the aeronautical arm. At least over the near term, the aeronautical portion will, to a large extent, rely on current status of structural, propulsion, aerodynamic and other technology that is available because of NASA and industry research efforts. While much of this effort has been integrated into civil products, the results are also available to our current military needs. It will probably take considerable time for the military research community to rebuild and mount the effective technology advancement research program needed to meet long term military needs. The previously planned NASA program would go far toward meeting that objective. The NASA facilities, technical expertise, and desire are in being and could serve in helping prepare industry to do what is necessary in meeting both the military and commercial competition that will face this nation in the future. Again it would be counterproductive to constrain the NASA program as indicated by the proposed fiscal year 1983 program.

[The following information was subsequently received for the record:]

Questions of the Committee and the Answers Thereto

Question 1. What are the effects or do you expect the effects to be of the Economic Recovery Act on the U.S. aeronautics industry research and development?

Answer. The Act shortened the depreciable life of R&D equipment from a minimum of 8 years to 3 years and reduced the investment tax credit from 10 percent to 6 percent. The net effect is that we anticipate no significant financial incentive as a result of these changes.

The Act also provides a 25 percent tax credit for certain research and development costs after June 30, 1981, but only to the extent that the current year expenditures exceed the average yearly R&D expenditures over a past base period. Our R&D expenditures are decreasing due to decreasing income as a result of the economic downturn as well as the fact that our intensive R&D efforts for Boeing's two new technology aircraft are being rapidly completed. Consequently we anticipate no significant near term tangible benefits from the tax credits.

We regard the provision that R&D tax credits are no longer available after 1985 as a majort drawback. To encourage the aeronautics industry to make major investments in new technology, we recommend that the R&D credits be extended indefinitely. We also recommend that the tax credits be allowed on a current expenditure basis rather than just an incremental basis to make the credit available to highly cyclical industries.

Question 2. What access do you have to DOD programs as compared to NASA? Are there time differences in acquiring DOD related program data as opposed to NASA? If so, what are these differences?

Answer. A great many of the DOD programs are classified. Because of this classification, technical information developed on DOD programs is not disseminated on a timely basis. NASA, over the years, has developed an excellent communication system for getting information to U.S. industry. This consists of reports, symposia and technical committee meetings.

Question 3. What percentage of your company's gross income is expended on your own R&D efforts?

Answer. During the period 1977 through 1981, the Boeing Company funded R&D to the following extent:

	1977	1978	1979	1980	1981
As percent of sales	5.5	5.1	6.5	8.1	8.6
As percent of pre-tax earnings	70.1	47.3	60.0	75.6	122.2

Question 4. Last year the Committee was concerned about the overall costs for the NAS. Consequently, the Committee asked NASA for a report on the description of the program, the status and to look at funding options. One option explored looks at a joint development program and recovery of capital costs. Could you please elaborate on your concerns about these approaches?

Answer. The NAS program is of a highly exploratory nature. therefore, no one at this time knows the relationship between costs and the value of the results. Once industry has experience in the use of this capability we would be willing to discuss paying for the service based on its value to us. If the charges were to be related to the value of the output, it would provide incentive for NASA to maintain a highly efficient system with improvements as new technology comes along. It would not be appropriate at this time to try to establish charges for this service.

Question 5. How important do you consider NASA's proposed program on the Numerical Aerodynamic Simulator?

Answer. Boeing considers NSAS's proposed program on numerical aerodynamic simulation to be very important. Because of the rapidly advancing technology in computer capability, this program is certainly on the leading edge of new technology and as such is a very appropriate effort for NASA to pursue.

Question 6. What might your position be to changes in the NASA enabling legislation which would permit the recovery of some facility R&D funds by NASA in their user fees for these facilities? What pricing structure would you propose?

Answer. For the most part, the capital costs of NASA test facilities are incurred because the facilities are needed to support government programs that are sponsored in the national interest over the long term. Their existence provides capability to this country that could not be made available because their cost could not be absorbed by individual, or collective industry members. Further, their use by industry maximizes their utilization for the good of the country. We therefore believe the current basis for fees to industry is fair, and it is in the best interest of the nation that amortization of original capitalization costs should not be charged to industry users.

Under current practices, the fees paid by industry are delivered to the Federal Treasury and are not credited to the NASA BUDGET. We believe one beneficial change to current practice would involve retention by NASA of the user fees for discretionary rehabilitation and maintenance of the facility from which the industry fees were derived. A sinking fund could thus be created, earmarked for use at that facility to provide upgrade and/or unusual maintenance. This fund would allow some longer-range facility improvements than now are possible since the current practice of budgeting provides for maintenance levels determined by experience in the previous year and results in mostly limited housekeeping maintenance. This approach would also emphasize the industry interest in certain facilities, as compared to others, and provide an independent indication of the usefulness of certain test facilities to the United States aeronautical community.

If the above fee retention by NASA were provided, it would be imperative that this income be treated as an incremental resource to NASA and not result in an equivalent subtraction of allocated budgets.

Question 7. What do you believe the proper balance should be between the NASA research and technology base programs and the systems technology programs?

Answer. The balance between NASA research and technology based programs and the systems technology programs should not be fixed at any specific level. It should be allowed to vary depending on circumstances within the industry. For example, the upper level of systems technology programs relative to NASA R&T base would be very appropriate at the levels reached during the ACEE program because of the pressure of the high fuel cost caused by the oil embargoes and the lack of industry financial capability to meet that challenge during the latter 70's. At other times when the industry is healthy financially and there are no externally caused crises such as the fuel situation, then the systems technology programs do not need to be as large a percentage of the R&T base as they were during the latter 70's.

Question 8. It's acknowledged that the number of foreign transport aircraft produced is being sold each year. What percentage of these aircraft contain U.S. parts and materials; i.e., power plants, avionics, etc.? Within each aircraft type, what percentage of U.S. equipment is on that type?

Answer. We do not have detailed information on the source of equipment used on the A300 and A310 transports. Both models use versions of the U.S. produced JT-9 and CF-6 engines, which probably constitute 20–25% (depending on spares) of the total cost of each model. They also include limited system components produced in the U.S. which would not increase the percentage greatly. As far as is known, the structure—which would be a high percentage item—is produced in the EEC.

Question 9. What would the effects be on your company, if the composite primary aircraft structure program is cancelled? To what extent are composite structures used on your Model 757 and 767 aircraft? What does this use of composites do for your program in terms of money and performance?

Answer. The NASA composite primary aircraft structure program has been postponed now for several years. As a result, The Boeing Company has moved ahead on its own based on the work accomplished on secondary structure on our Model 757 and 767 aircraft. Therefore, the cancellation of this program would not affect Boeing. The weight savings resulting from the application of composites in secondary structures has been 1300 lbs. on the 767 and 1400 lbs. on the 757. The somewhat greater savings accomplished on the 757 resulted from the learning experience in the 767.

Question 10. You mentioned in your written submitted statement that ". . . it will probably take considerable time for the military research community to rebuild and mount the effective technology advancement research program needed to meet long term military needs." Would you please elaborate on this?

Answer. As indicated previously, much of the status technology available to meet short term military needs has resulted from NASA programs. It required much time for the NASA to build the organizational structure and overall capability to carry out those programs. Additional time was spent in developing the individual program plans, obtaining the funding and carrying out the research programs.

With limited funding, the military have had to concentrate on keeping their current equipment in ready condition and have not been able to maintain laboratory facilities and expertise, or the overall organizational structure required to pursue research that will meet long term needs. This has particularly been the case in those technology areas where NASA programs were known to be effective. It will take time to build that capability.

Question 11. Is the current airline recession a worldwide problem? If so, has your European competition, Airbus, had any cancellations or stop work similar to those recently experienced by your company? What do you recommend to alleviate this situation?

Answer. The current airline recession is a U.S. and European phenomenon primarily. Traffic growth, though down, is still positive in Africa and South America. The Indian subcontinent, Middle East, and Asia outside of Japan all enjoyed double digit growth in 1981. Only the U.S. has suffered two consecutive years of negative growth (1980–1981).

Airbus cancellations have come only from Freddie Laker. Seven A300's were cancelled as a result of his bankruptcy. We are not aware of any other negative impacts on Airbus production. They currently have an announced backlog of 78 A300's, and 90 A310's. The A310 is scheduled for first delivery in 1983. Work on "filling the pipeline" is proceeding without apparent difficulty. It is true that several carriers, notably SAS, perceive their current in-service A300's as too big. They would like to sell them, but as is the case for other wide body airplanes, the market is very soft. Conceivably, with some additional traffic recovery in Europe and Africa, a secondhand market for these airplanes might develop. In that case, Airbus sales of new airplanes might be adversely affected until some secondhand units were absorbed.

As you are aware from recent press accounts, American Airlines in late February of this year concelled its order for 15 Model 757 aircraft, valued at about $600 million, and scheduled for delivery in 1984–1985. It also cancelled options for 15 additional 757 aircraft. The carrier cited inadequate earnings and a "discouraging" outlook as reasons behind their "reluctant" decision. Chairman, *Albert* v. *Casey,* is quoted as saying "There simply is no assurance that we can raise the necessary funds to acquire the 757." The carrier attributes recent losses and lower revenue to "excessive discounting of airline fares" by competitors and refusal of its union employees to accept proposed productivity improvements and other concessions.

There are several government actions that would have a positive impact on our commercial airplane sales. First, we are against outright repeal of the Safe Harbor Leasing provisions of the Economic Recovery Tax Act of 1981. While Boeing has not utilized Safe Harbor Leasing, it is critical for many of our customers for several reasons:

Whatever means are used to encourage capital investment in productive equipment, the rules should not be changed frequently. Capital equipment decisions; e.g., commercial airplanes, require long lead times between order and financing on the one hand and delivery and placement in service on the other. It is unwise and unfair to change the rules on Safe Harbor Leasing enacted only a short time back on August 13, 1981, because of a few unintended and undeserved results.

Safe Harbor Leasing is working for the airlines as it was intended when enacted by Congress. It's enabling companies in a currently unprofitable industry to finance the purchase of new more efficient equipment they have ordered. It is apparent that without Safe Harbor Leasing provisions, airlines may be unable to honor their commitments. Cancellation or delay would have a significant impact on employment at Boeing and its vast supplier network throughout 46 states and the District of Columbia.

Air Transport Association (ATA) President Paul Ignatius in a March 1, 1982 letter to Senate and House members stated that repeal of Safe Harbor "could force the airlines to cancel or defer many of the aircraft on order or option through 1985." There are 400 aircraft on order or option, with related spares and ground equipment worth $15 billion, through 1985 according to ATA estimates.

United Airlines, in recent press reports is quoted as having "notified The Boeing Company to stop work on 20 new-generation 767 twin jets, worth nearly $1 billion" pending resolution of Congressional action on the Safe Harbor Leasing provisions. Frank Borman, Chairman, President and Chief Executive Officer of Eastern has also been quoted as saying in testimony before the Senate Finance Committee that repeal "would put in question $1 billion worth of procurement" of Boeing 757s if Eastern is precluded from utilizing Safe Harbor Leasing.

If problems have arisen because of some unintended results, they should be addressed by appropriate amendments rather than repeal. We understand that Senator Durenberger of Minnesota has drafted a reform measure which addresses those problems and preserves the basic effectiveness of the legislation. Boeing would support such a proposal; however, any changes to the provisions of Safe Harbor Leasing should not be made retroactive. We are further aware that the ATA, representing this nation's scheduled airlines is willing to support compromise to eliminate any perceived abuses.

Second, we support a strong Ex-Im bank which has the funds and commitment to match financial offers of our foreign competition. Over half of our projected sales for new airplanes are to foreign carriers. We are competing against an airframe manufacturing consortium whose development, manufacture and marketing costs are underwritten by host governments. The Boeing Company, as a private corporation, cannot compete against the financial resources or the governments supporting the Airbus consortium. Until the financing issue in the sale of airplanes has been neutralized, we will need Ex-Im support for many overseas sales.

And third, we think that interest rates are too high for this stage of recession. The Federal Reserve's single minded pro-occupation with controlling the money supply in a seriously depressed economy has driven interest rates in real terms to an all time high. They should come down. In concert with a drop in interest rates, we believe the projected Federal deficit should be lowered by lowering spending, not raising taxes. The fear of "crowding out" on the part of the Federal Government in the financial markets is very real and is a major contribution to continuing concern about high interest rates and a resurgence of inflation.

Senator SCHMITT. Well, then, do you think there is any potential within the private sector acting by itself, unless you can assume interest rates are significantly lower than today, to undertake a propfan technological development that might cost as much as $200 million?

Dr. SHANK. I would like to respond to that, Senator Schmitt. Of course the first thing that has to be done on a propfan is the upfront proof-of-concept work.

The principal proof-of-concept items which must be demonstrated are cabin noise reduction; propellor structural integrity and aerolastic stability; gearbox reliability and systems integrity of the propeller, engine and aircraft. You need to understand a great deal more about how the propeller, the engine, and the aircraft all fit together and what the industry calls the installation aerodynamics—how the engine is mounted on the wing—which affect not only the aircraft but the engine itself. All of these items together involve the disciplines of companies that make airframes, engines, and propellers.

Our company's resources are required for 24 commitments that we have made to customers on our present and forthcoming products, particularly the continuing improvement of the JT–9D engine series, and the development and certification of the PW–2037.

Given our industry's near-term funding requirements, it is unlikely that U.S. industry could commit funding for the proof-of-concept work in a timely manner.

In addition, as Dr. Demisch has mentioned, it has to be remembered that once the proof-of-concept work has been demonstrated, we would have to commit about $1 billion of our own funds to develop and certify the engine.

I also want to say that even if the money were available, you need the synergism of people and facilities from NASA and many companies which can only be brought together under auspices of NASA.

My company competes in a most aggressive manner with our competitors. Nevertheless, we have the greatest respect for competing companies, and I believe they have respect for us. Thus I believe that the final technology would be greatly enhanced by NASA as a Federal agency working with all capable parties in the United States.

Senator SCHMITT. Well, let me assume, then, that NASA went ahead with the technology development to the point of where the product development would require a $1 billion investment by one or more companies. Would there be an incentive for the U.S. engine companies to move forward with a propfan, or is that something that would be transferred immediately abroad and we would find that the propfan would be sold by Rolls-Royce, a Japanese firm or some other source?

Dr. SHANK. From proof-of-concept technology we derive two things: The first is leadtime. The second is the opportunity to study the risks of future development. Without performing such proof-of-concept work, no sensible risk assessment can be made. The transmission of our technology abroad is another question which you may like to explore later, but for the moment I would just like to stick with this.

Would we develop it if the technology were available and we saw the market? We have never been unwilling to accept the responsibility associated with the development of high technology, advanced new concepts and products for the market. We are going forward with our newest, most advanced engine, the PW-2037.

Senator SCHMITT. Any other comments?

Mr. DONOHUE. I think the perspective has to be expanded just a small amount in that the engine manufacturers do not go ahead and produce engines or propulsion systems, including propellers, without there being a commitment, a very strong commitment, and to the development of an airplane.

In reality, when we talk about the propfan program we are really talking about an integrated system in which we have to understand the flow fields over the wing, installation of the propellers, as well as the propeller itself. It is someplace down the road from the initial experiments that will indicate whether or not an airplane can be made.

Then, once an airplane is makeable, one can go ahead and decide to build the engine.

Senator SCHMITT. Mr. Withington, would you have any comments in that regard?

Mr. WITHINGTON. The decision to proceed with a product requires a great deal of homework, that homework is the $200 million number that you mentioned.

I would have to say that without NASA supplying that, as far as my company is concerned, we would not be, at this time, able to spend that kind of money to do that homework. So without the NASA program, as far as we are concerned, we would not get that homework done and we would not be in a position to even make the decision.

Senator SCHMITT. Is the implication, then, that throughout most of the history of the U.S. aircraft industry that manufacturers of aircraft systems have invariably drawn on a reservoir of technology that NASA and its predecessor created without knowing whether that technology in the process of being created was going to be useful or not or utilized or not?

Mr. CLEVELAND. Well, it is too hard to answer something like that simply. The technology covers a spectrum and certainly some of it is applicable without any further work by anybody except the application by the user.

Way out on the other end is that which is very much less certain, and if that is also mixed in with the market uncertainty, which was the question I actually asked, then, of course, somebody has got to go a great deal farther before you will make the big investment commitment.

Senator SCHMITT. How can the Government make any kind of judgments on future commercial applicability on major technological investments? Do we have to make them on faith that the chances are that 89 percent of them will be used in the case of the military?

I mean, is there enough historical basis for that faith, or do we have some kind of a critical path already laid out to where propfan technology is going to end up on a flying commercial airplane with people filling all the seats?

Mr. CLEVELAND. That is more like the socialist Russian way of doing it. You make a decision like that and you make everything drive to make the decision come true. That is a self-fulfilling decision.

The NASA people have not only the benefit of many years of experience in watching their technology being applied—and in some cases not being applied—and having a tremendous dialog with industry. They are very good listeners, and then they go back home and make their judgments as to where it looks like certain technological commitments on their part should be made.

In many cases they feel they have now gone far enough: either it is not going to be applied and we should not do much more work because it does not have any more promise, or we have gone as far as the Government ought to go in this regard and industry will pick it up.

But there is a very excellent dialog which goes on more or less continuously which guides their judgment by their willingness to listen to the individual judgments of people like ourselves—which are not in agreement all the time and in fact in substantial disagreement in some technical areas.

Senator SCHMITT. So the success of a research and technology program in aeronautics or probably any other field is dependent on good people using good judgment and having the adequate resources to exercise that judgment.

Mr. CLEVELAND. Amen.

Senator SCHMITT. And it cannot depend on whether or not there is already a design crew working at Boeing or Lockheed or Pratt & Whitney or GE or somewhere else, or Lear, to put together a design to which that technology is going to be fitted before you know what it is.

Mr. CLEVELAND. Correct.

Mr. WITHINGTON. Incidentally, turboprops are not the only technology in this area. Take laminar flow, for example.

Let me go back a bit in history. In 1975, I believe, right after the oil embargo and the crisis for getting better fuel economy, Bisplinghoff, Dr. Ray Bisplinghoff, was chairman of a committee consisting of industry, academia, and NASA to see what we could do to improve fuel economy of our aircraft. We had several meetings and the general consensus was that there were a lot of potential items, a lot of technologies that had a very high potential but that were very high risk.

They would take a lot of time and money to develop. At that time certainly no aircraft company had the capability to do it. That was what formed the basis of the ACEE program back at that time.

I remember very well taking a vote one day relative to the importance of these programs and the relationship between that importance and whether or not NASA should fund them. I think it was generally the feeling of industry that it was most important for NASA to help us with those items that had perhaps the biggest potential payoff but also had the biggest risk, and probably the head of that list was laminar flow with turboprops further down the priority.

So I think that ACEE program was an excellent program. It tried to work the tough problems, the ones that had a very high potential payoff but also a high risk. I think that is the area where NASA can be very, very helpful. None of those programs would have been worked at that time without NASA help.

Senator SCHMITT. Are there any circumstances under which industry would work those kinds of programs?

Mr. WITHINGTON. Those programs in my opinion are too high risk, too far off.

Senator SCHMITT. Under any kind of financial assistance?

Mr. WITHINGTON. Well, certainly anything that I have seen in my 40 years in the industry. We certainly cannot afford to spend money on high risk, very long payoff areas. It is tough enough to establish a production program like we do today where we will not break even for at least 10 years if we are lucky.

Senator SCHMITT. Is that because large, established manufacturers become very conservative or stockholders will not allow it?

Mr. WITHINGTON. We get accused of that. I think we are very brave, frankly. I do not think any other industrial people in the world bet as much as we do on its products with the payoff so far off. I am not a bit ashamed of what we are doing.

Senator SCHMITT. Unless it is the farmer planting his crop every spring.

Mr. Neal?

Mr. NEAL. Let me cite an example to partly answer maybe a part of the question that you asked. We are a small company, about $500 million a year, which is strange to think we are small, but we do not have the resources to devote part of our engineering department to do flight testing of laminar flow research.

We are just not that big and it is just not that near at hand. However, NASA has had an ongoing program to look at laminar flow. They had developed some techniques to do in-flight flow visualization. Through a cooperative program between NASA and ourselves, they had the technique. They had not been able to expand it to Mach number altitude, Reynold's number capability that we operate in.

So they provided us with the technique, how they did it, the material to use, their experience in the flight test. We provided the airplane, carried out the experiment. They got the data. We got the knowledge of the technique and there were no dollars exchanged.

We did not write any contracts. No big deal out of it—very simple, very straightforward, but a clear exchange of technology to both of us—in our case the technique; in NASA's case particular data.

Senator SCHMITT. And there is a restriction on NASA in publishing the results of that experiment?

Mr. NEAL. No, and that is an issue that comes up and we recognize that risk. I think it was answered because we got it first and if we are not smart enough to do something with it, we take our licks.

The supercritical wing or the supercritical airfoil is another example of that where the technology was available to industry in terms of the documents that we had available well before it was published in any open literature. It was up to us to use it, and in the case of my particular company finances did not permit it, but other people did.

But that is a risk you take and we are willing to take it for the advance of the technology.

Senator SCHMITT. It has been said that the reason for the past success of U.S. transport aircraft industry activities has been due to the aircraft being initially designed and sold in the domestic U.S. market. Do you agree with that and, if so, is the current U.S. transport aircraft market strategy different than it was in the past?

Are we designing more for world market than any domestic market or is there any difference?

Mr. WITHINGTON. I think it has been true that the first customers for most of our programs have been U.S. airlines, but this is not necessarily always the case. For example the 757 had both Eastern and British Airways kicking it off.

In our opinion we are really working for the world market. Approximately 60 percent of our sales are outside of the United States, so as far as we are concerned it is a world market.

Senator SCHMITT. How does that specifically affect the design of the aircraft? In terms of its maintenance design, does that affect it more than other aspects?

Mr. WITHINGTON. Basically a good airplane is a good airplane, regardless of where it is sold. There is no significant difference. We certify basically to the FAA standard. We have to do a little bit of extra work with the CAA in Britain and some of the other certifying agencies around the world, but it is relatively minor.

We design basically to U.S. standards and they are pretty much accepted throughout the world.

STATEMENT OF DR. ROGER D. SCHAUFELE, VICE PRESIDENT FOR ENGINEERING, DOUGLAS AIRCRAFT CO., McDONNELL DOUGLAS CORP.

Dr. SCHAUFELE. I would like to add to that. I think it is basically the technical quality of the product that the designers work on and it really makes it a true, useful product for the entire world. It has to be not only fuel efficient, low operating costs, but also has to meet environmental standards. I think those are the aspects of the commercial transport programs that I have been involved in that make it a true world product.

[The statement follows:]

STATEMENT OF DR. ROGER D. SCHAUFELE, VICE PRESIDENT, ENGINEERING, DOUGLAS AIRCRAFT CO., McDONNELL DOUGLAS CORP.

Mr. Chairman and members of the subcommittee, thank you for the opportunity to present comments on the NASA Aeronautics Program. Along with other members of the aeronautical community, we are deeply concerned with the size of the NASA aeronautics budget and the repeated attempts to reduce it even further. The continued attack on this unique national resource will have severely damaging effects on the technological foundations of our commercial and military aircraft leadership. The nation cannot afford economically or militarily the continued erosion of the innovative cooperation between NASA, the military services and the manufacturing industry that has made the United States the world's largest producer of efficient and economical commercial transports, as well as sophisticated and highly capable military aircraft.

NASA, and its predecessor agency, NACA, have had the primary federal responsibility for aeronautical research and development for over 66 years, and these agencies have discharged their responsibility with outstanding success. The balanced approach to aeronautics technology development, involving fundamental analytical studies, small scale laboratory experiments to support the basic principles, and finally, full scale flight verification, pioneered by NACA, resulted in many significant contributions and was a vital element in the rise of the United States to a position of preeminence in civil and military aeronautics throughout the world. The unique cooperation between NASA, the military services and the aviation industry has eliminated duplication and fostered synergistic progress in key disciplines, while allowing true competition to take place in innovative product application. This formula for leadership is being threatened by continued assaults on the NASA Aeronautics Program. The fact that NASA's Aeronautics Program has not been expanded to take advantage of the potential opportunities for aeronautical technology advancement has already caused serious damage to the once dominant position of the U.S. civil transport industry.

For the last 50 years, reliable, efficient and economical commerical transports, designed and produced in the United States have captured over 90 percent of the world market. This acceptance of our products worldwide was due to the combination of the continuing advances in aeronautical technology fostered and developed by NACA and NASA and the incorporation of these advances in specific products by the aircraft manufacturing industry. There was also additional synergism afforded by the military aircraft developments early in this period but this stimulus to commercial aircraft has waned in recent years due to the increasingly diverse requirements for advanced military aircraft as compared to commercial transports. Significantly, other countries have recognized the importance of a strong commercial transport manufacturing industry to their national economies and the underlying need to support vigorous aeronautical technology programs. In France, Germany and Japan, for example, there are strong government supported aeronautical technology programs, staffed by well trained scientists and engineers, working in new laboratory facilities and in close cooperation with the manufacturing industry to identify and bring to production applicable advanced technology.

These efforts have been going on for a number of years, with corresponding success in the development of technically competitive commercial jet transports. The European A300, A310, and proposed A320 are the result of major government investment, not only in the technology development but also in the actual production and marketing efforts. The impact on the United States leadership is already seriously evident. In 1976, the United States commercial aircraft industry booked orders for wide-bodied jet transports amounting to 97 percent of the total orders with 3 percent going to the European Airbus consortium. In only 3 years, the European Airbus share had risen to 31 percent of the total wide-body booked orders. Such progress in the comercial jet transport business is the result of a strong team effort involving government supported research and technology, aggressive application of the technology by a strong manufacturing industry and innovative financing through the cooperative efforts of the financial community and appropriate government agencies.

As the United States entered the space age, the aeronautical research and technology activities of NASA did not keep pace with the erosive forces of inflation. This shift in emphasis from aeronautics to space resulted in a reduction in NASA's contribution to the Nation's aeronautical research and technology base. One notable exception was the NASA refan program, a cooperative systems technology effort involving United Technologies, Boeing and McDonnell Douglas under NASA direction which demonstrated to low noise and improved fuel efficiency of the JT8D refanned engine in both the 727 and DC-9 aircraft. This program was the demonstrated proof of concept basis for the quiet, fuel efficient McDonnel Douglas Super 80 aircraft program of today. In 1975, after almost two decades of reduced emphasis on aeronautics, Congress recognized the threat of foreign competition and increasing energy costs and directed NASA to formulate a program to enhance the applications of advanced technnologies in aeronautics. The resulting Aircraft Energy Efficiency (ACEE) Program has allowed NASA to conduct technology development in several important areas enabling industry to incorporate these advanced technologies in their future designs. The areas of technology development included composite structures, advanced aerodynamics, flight controls and propulsion. This committee is well aware of this program and we want to complement Congress and NASA on the valuable contribution these ACEE programs have provided to our industry.

There are some long-term technology developments that might allow the United States industry to leap frog the foreign competition if these programs were to continue according to the original plans. These areas are Large Composite Primary Structures, Advanced Propfans and Laminar Flow Control. The NASA program should take these concepts to large scale ground and flight tests in order to evaluate and understand the technical merit and generate industry and user confidence that the risk in making a design application can attract private capital investment. The advanced supersonic technology program should also be in this category. The role of the military in aeronautical research, specifically as applied to commercial transports, has changed over the years. In the years during and after World War II, research and development by both NASA and DoD provided industry with the knowledge and capability to generate its products used worldwide. In today's environment the military generates very little technology applicable to commercial transports, with most of their development going to extremely high performance combat aircraft, space or missiles. In fact, new military transport aircraft are utilizing the NASA sponsored systems technology developments in propulsion, aerodynamics, controls, structures and materials. The McDonnell Douglas C-17A Air Force cargo transport design contains many spin-offs from NASA research and development such as the advanced supercritical wing, winglets, composite materials and active control systems. For future transports, the Air Force and Navy are not actively conducting any research on the Advanced Turboprop and Laminar Flow Control concepts and their activities on large composite primary structures are not directly applicable to transports.

NASA is the federal agency with a charter to maintain the United States as a leader in the world's civil aeronautics field. The NASA aeronautics effort is a small portion of the NASA budget, but it is the part that has a large payoff in our national economy. NASA needs to reestablish an aggressive program that addresses not only aeronautics research and technology base but also expands its role in systems technology studies and support to joint industry development programs on high-risk technologies applicable to the civil transport marketplace. A strong research and technology program is the basis for technologically and economically superior aircraft. Our past history in the United States as well as the recent example in Europe has shown that government management and financial support through an agency like NASA is essential to bring together the technical expertise needed to address all of the aeronautical technology with potential for future application. Technical innovations in the aircraft manufacturing business is so complex that no individual company can possibly know all the variables or have all the talent that is involved. The special talents and motivations required for innovative and creative development are contained within a fairly small percentage of our total scientific and technological community and are distributed throughout the aerospace community. The major contributions of this group of people to our national strength should not be stymied by duplication of effort, unnecessary redundancy, constrained communications, lack of recognition; all of which would result if individual companies are left to their own devices.

Even if it were possible for industry to accomplish the task as conceived, development by industry of competent staffs and expensive facilities would take a very long time and would leave the United States in a period of technological "depression."

Even if special economic provisions were provided which made the extra industry expenditures possible, there would be a wasteful duplication of facilities.

Foreign competitors in the field of aeronautics are heavily supported by their governments. The United States would be left behind during the period of time industry would be trying to regroup from lack of support by the United States Government.

In the foreseeable future, it is financially impossible for the industry as a whole to pick up the slack.

Private industry already obligates large amounts to product development and aeronautics technology; however, "long lead times" associated with basic research force the industry to appropriate a relatively small percentage of its financial resources to this end.

We support and are encouraged by the efforts to bring fiscal responsibility to federal government and reduce its spending. But we urge support for the key federal research activities that have favorable and highly leverage impact upon the productivity and technological strength of the aeronautical industry. The NASA aeronautical budget is such a high-leverage activity.

Senator SCHMITT. Are your foreign competitors designing their aircraft for the U.S. market in any special way or is it also a world market for which they are designing?

Mr. PARMET. Can I take a shot at that? As a user now, keeping the manufacturers off the hot seat, we compared two vehicles at our airline. One was the Airbus 310 and the other was the Boeing 767. Both were designed to do essentially the same mission. They were designed with different concepts, especially in the aerodynamic aspects of it.

The 767 had a much larger, high aspect ratio wing. The Airbus had a smaller wing. So you looked at these two designs and you saw that the Airbus was tailored more for a European environment and at route distances less than 900 miles the Airbus appeared to be slightly more efficient and probably will be.

At the longer ranges, like in domestic United States where you go New York to Denver or New York to Los Angeles, the 767 is going to come into its own in that type of mission. But it also has an advantage overseas in the longer range operations there.

Any manufacturer that does not consider the world marketplace is crazy today. But yet if one evaluated these two airplanes on an overall basis and did a bottom line analysis, financial analysis, they are so close they just lay right on top of each other.

Senator SCHMITT. What about quality control in that kind of technology?

Mr. PARMET. American manufacturers have been known for very fine quality control for years and I have got to assure you that having been at the Airbus headquarters and the manufacturing facilities they have very high quality control. Their product from that standpoint is every bit as good as the American product.

Senator SCHMITT. I have been told that the productivity of the Airbus line is significantly less than the productivity of the U.S. aircraft line. Do you agree with that, that if they were really and truly competitive in the world market their labor costs would be——

Mr. **Parmet**. I cannot answer your question. I think they have gotten far more productive than they used to be because I went to that same facility and watched the Caravelle being produced. You could hardly see the airplanes for the manpower on top of them.

The Airbus facility looks like an American facility in the manner of manpower associated in actually doing the work. Now European labor agreements, I think, are different than American ones and they provide more people just to stand by, for all I know, so I really cannot answer the total. But they are learning from what the American manufacturers have taught them, and they are learning it well.

Dr. **Shank**. Senator, I would like to mention something on productivity, if I may. You know, as is the case with all the manufacturers sitting at this table, all of our money comes from customers. We have no qualms about competing in the marketplace in the true free enterprise system.

But several years ago our principal foreign competitor, Rolls-Royce, went bankrupt. It was rescued by the British Government. It is now a State corporation.

I would note that Rolls-Royce does roughly half the dollar volume of business that Pratt & Whitney does, yet they have twice the number of employees.

Now I do not know how you do this and stay in the business unless you are essentially a government-funded employment agency. It is very difficult for any private corporation to compete with the taxing authority of a foreign government.

Senator **Schmitt**. Mr. Withington looks like he is anxious to make another comment.

Mr. **Withington**. We have talked a lot today. In fact, the purpose of this meeting is to try to get a better understanding of the importance of NASA to the technical aspects of our business.

We have also alluded to the fact that our competition is supported on a financial basis differently than we are. I would like to offer just as a matter of information, that there is a tradeoff between the financing and the level of technology which I think is worth commenting on.

If you take 1 percent difference in financing interest charges and you try to offset that, which is the only thing we can do, with a better technology—in other words, less fuel burned—we have to do about 1 percent better on fuel burned to match a 1-percent difference in interest rates. It is a kind of neat set of numbers that is easy to remember.

That is the leverage of improved technoloy to offset more favorable financing What we are talking about here today is to get as much assistance as we can from the government through NASA to do a better job in technology so that we can offset that financing.

There was a lot of discussion here earlier about getting control of the financing situation, but it does not seem to be happening very quickly and since I am a technician I want to try to work the problem from the technical side. We might remember that it takes about 1 percent better fuel burned to match a percent difference in financing.

That is the leverage that technology has.

Senator SCHMITT. However, it is a lot easier for a foreign government to reduce the effective interest rate than it is for us to move forward a more efficient engine technology or aircraft technology. How do we deal with that—easier in terms of a political environment, if not a technical environment.

Mr. WITHINGTON. I completely agree. It is a tough situation but the only thing we can do from the technical side is to do the best we can technically and the relationship with NASA over the many, many years is very unique and important, has helped us to be better technically.

I am optimistic. I think we are slightly better still today technically, but it is not enough to overcome some of the other aspects such as financing.

I would like to present some numbers to indicate the specific inroads that the Airbus industry has made on our sales situation over the last few years. For example, in 1976 Lockheed, Douglas, and Boeing announced orders for 109 units; Airbus for 7 units. That was in 1976. In 1981, our combined U.S. manufacturers announced orders for 113 against 55. In other words, we went up a little bit; they went from 7 to 55.

Another kind of interesting comparison is the specific competition between the Airbus A-310 and our 767 and 757. In 1981 we only announced orders for 16 units outside of the United States and the A-310 announced orders for 19, so there is an indication that things are getting really rough in this competition and the only way that us technical types can fight that is with better technology.

That is why we are here to highly recommend that the Government continue to support aeronautical research through NASA. It is a good system.

Senator SCHMITT. What would be the effect of a 5 percentage point reduction in interest rates purchasers of U.S. aircraft would have to pay over the length of the financial arrangements?

Mr. WITHINGTON. I cannot answer that precisely. I am an aerodynamicist but I think it is a very large number.

Senator SCHMITT. Five percent would make a significant difference in those numbers for the next competitive period, is that correct?

[Witnesses nodding in the affirmative.]

Senator SCHMITT. Would it be difficult for a foreign country to match that kind of a change in domestic interest rates?

Mr. NEAL. I think that depends on their national policy. We in our segment have seen specific cases in competition head on with foreign aircraft where they are cutting prices to the point that we just—how do you cut $800,000 off of a $5 million product? We are seeing that in certain cases. We are seeing very tough competition and it has to be through support of the governments.

Senator SCHMITT. Well, we are seeing it in satellites and other areas too.

Mr. NEAL. If I might, I would comment on one other issue which you brought up and that is I may be unique amongst this panel in that I have worked for a foreign manufacturer in a foreign country owned by a foreign government.

I would say that their manufacturing capabilities, their ability to buy machinery is equal to ours. Their equipment is first class. They are motivated by the same thing that drives us, which is to get the manpower out. The political consideration can enter into certain of these questions, and their technology can approach ours.

The advantage that many of the foreign countries have is direct support in terms of sales and international sales. The governments are involved in the sale of products either directly or indirectly, which we do not have.

I think as I said in my——

Senator SCHMITT. You are not advocating that we get the government involved in sales, are you?

Mr. NEAL. No. That is what I am saying. I think we want to fight head on in that international competition and we can do it and we can be successful, but one edge is our technical edge and that is through the R. & D. effort.

Senator SCHMITT. Well, I have explored the financial side of this thing and the political side of this thing extensively because every time we get into it you come back to that the critical edge is in the technology and if that starts to disappear, then the numbers that Mr. Withington just read will only get worse.

Is that the general conclusion of all of you?

[All witnesses nodding in the affirmative.]

Senator SCHMITT. Heads nod. Let the record show that every member of the panel nodded their head yes.

Gentlemen, if we may we will have some questions for the record for each of you. I hope that we can get brief answers to them. This is not an insignificant part of the total scheme of things nationally. I think you all would agree.

Maybe one difficulty we have with NASA programs, whether they are space or aeronautics, is that the numbers are not as big as the numbers in other Federal activities and people think that their significance is somehow measured in direct proportion to the numbers of Federal dollars involved. Obviously that is not true.

You have helped us very much with your detailed, quantitative portrayal of the aeronautics industry, its relationship to domestic and foreign sales. Clearly, if we continue to deemphasize the research and technology in aeronautics at the same time we are deemphasizing research and technology in agriculture we are undercutting the two areas that contribute most to our balance of payments.

It is almost inconceivable to me that we would be taking steps that literally kill the geese that lay golden eggs in the economy of this country, and we are talking about extraordinarily small amounts of money to keep that goose not only alive but fat and laying very well.

So we will do the best we can here to insure that you continue to have the opportunities to compete fully and fairly in the world markets.

Thank you, gentlemen. We will have questions for the record.

The hearing is recessed.

[Whereupon, at 12:29 o'clock p.m., the subcommittee adjourned, to reconvene upon the call of the Chair.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF DEPARTMENT OF ENERGY

INTRODUCTION

The Department of Energy (DOE) and the National Aeronautics and Space Administration (NASA) continue to have cooperative programs which encompass work on a wide range of technologies in both energy and space-related fields.

Much of NASA's expertise is directly applicable to a large portion of the Department's energy research and development mission. NASA centers of excellence have personnel with the requisite skills for resolution of certain key energy problems. Therefore, DOE places a high priority on continuing the long-term relationship between DOE and NASA organizations as we refocus the government's role in many areas of energy research and development to emphasize long-term, high risk activities.

The reimbursable program relationship between DOE and NASA was formalized with the signing of a Memorandum of Understanding (MOU) on March 21, 1978. This MOU documented a policy supporting DOE use of the expertise and personnel at NASA Centers and vice versa—a policy which works to the benefit of both agencies and the public.

It was agreed that NASA would carry out DOE funded research at selected centers in specific disciplines and technologies, submit proposals to DOE for specific technology development activities and provide technical and administrative management support. Tasks performed for DOE would be budgeted and accounted for through DOE's normal budgetary processes, with DOE providing for the costs of NASA civil service personnel, contractor support and other appropriate costs. Overall policy and yearly budgets, as well as cross/cutting issues which arise during the year, would be addressed by NASA and DOE top management. Attachment A contains a current list of DOE/NASA Program Coordination Committee members.

During the past year, DOE and NASA worked on projects in the areas of conservation, solar applications and solar technology development, geothermal energy, fossil energy, environmental research and development and space applications. During the forthcoming fiscal year (fiscal year 1983), the total DOE cooperative program with NASA is estimated to be approximately $43.8 million. Attachment B contains fiscal year 1982 and fiscal year 1983 funding summaries for each category of continuing programs with NASA. These numbers reflect only the portion of each DOE program budget that is expended on work with NASA, thus they do not represent the total program funds included in the President's budget.

DOE COOPERATIVE PROGRAMS WITH NASA

The DOE/NASA cooperative work is primarily energy-related with a variety of projects falling under the purview of five separate DOE organizations. The major portion of the work, which is reimbursable, falls under the Assistant Secretaries for Conservation and Renewable Energy and Fossil Energy. Currently, direct funded efforts are also supported by the Assistant Secretaries for Nuclear Energy, and Defense Programs, and the Director of Energy Research.

Specifically, the Assistant Secretary for Conservation and renewable Energy utilizes support form NASA during fiscal year 1982 in seven programs as follows: Vehicle and Engine Research and Development; Energy Systems; Wind Energy Technology; Photovoltaic Energy Technology; Solar Thermal Energy Technology; Biomass Energy Technology; and Geothermal Energy Technology.

Funding for the eighth program, Solar Heating and cooling, was completed in fiscal year 1981 and termination is now in progress. Of the seven current efforts, two—Energy Systems and Solar Thermal Energy Technology—are being concluded in fiscal year 1982. Three are projected to be concluded in fiscal year 1983. They are Vehicle and Engine R&D, Wind Energy Technology and Geothermal Energy Technology.

The Vehicle and Engine Research and Development program is supported by the Lewis Research Center (LeRC) and the Jet Propulsion Laboratory (JPL). This program as such is concluding in fiscal year 1982. For fiscal year 1983, concluding and some continuing efforts in this area will be supported under the Energy Conversion and Utilization Technologies (ECUT) program, and LeRC will participate in these efforts. The Energy Systems Research program is supported by LeRC and JPL in fiscal year 1982. NASA participation in these efforts will not continue in fiscal year 1983.

LeRC provides R&D and management support to the Wind Energy Technology program in fiscal year 1982 and will conclude this support in fiscal year 1983. JPL and LeRC provide support to the Photovoltaic Energy Program. The LeRC efforts are being concluded in fiscal year 1982 except for a small international activity in cooperation with the Department of State. The JPL activity, involving both management and the conduct of a Flat Plate Solar Array project, is continuing through fiscal year 1983.

JPL is concluding its efforts in fiscal year 1982 in support of the Solar Thermal Energy Technology program. JPL efforts in support of the Biomass Energy Technology program are continuing through fiscal year 1983. The JPL research in support of the Geothermal Energy Technology program will conclude in fiscal year 1983. The Marshall Space Flight Center support of the Solar Heating and Cooling program was concluded in fiscal year 1981.

The Assistant Secretary for Fossil Energy will continue to receive support from NASA in several coal-related long-range, high-risk R&D programs, however, no new funds are requested in fiscal year 1983 for cooperative program activities. Joint projects in such areas as control technology, heat engines, fuel cells, and mining research and development will be funded with fiscal year 1982 and prior year funds, and much of the work will begin phasing out this year and during the early part of fiscal year 1983.

In the control technology area, NASA will continue to investigate means to chemically remove organic and inorganic sulfur from coal. In the area of heat engines, NASA will continue the development of the technology for low nitrogen oxide combustors through small scale tests of risk hardware. Research done to date on this advanced technology has established a sufficient data base so industry is capable of completing its development and commercialization; therefore the Department plans to conclude this program in fiscal year 1983 and has requested no new funding. Through the first hjalf of fiscal year 1983, NASA will also be responsible for certain management activities in the phosphoric acid fuel cell development program through its Lewis Research Center. The DOE/NASA Interagency Agreement for fuel cell support is being examined for possible termination by approximately December 1982.

NASA centers are also involved in several DOE mining R&D projects aimed at (1) increasing mine productivity and reducing costs by automating mining systems, including longwall instrumentation, control and diagnostics; and (2) assessing advanced underground coal mining systems. DOE is proposing to transfer the mining program in fiscal year 1983 to the Department of Interior where it would be combined with similar R&D activities now underway to improve the health, safety and environmental impact of coal extraction.

The ongoing project for the Director of Energy Research is a high-altitude atmospheric sampling program aimed at the development of models of the stratospheric movement of pollutants.

DOE will provide support for NASA's biomedical research aimed at estimating the effects on long-term human exposure to high energy heavy ions. This research will continue to be conducted at the BEVALAC, the high energy heavy ion accelerator facility at DOE's Lawrence Berkeley Laboratory.

The Assistant Secretary for Nuclear Energy is responsible for DOE's nuclear power program in support of NASA's mission. These activities, DOE-funded and managed, focus on the development of compact nuclear power systems for use in space exploration. In fiscal year 1983, the two major projects will be support of the NASA Galileo and the International Solar Polar spacecraft missions. The latter is a joint NASA/European Space Agency (ESA) out-of-the-ecliptic mission about the sun using an ESA spacecraft and NASA launch vehicle. Specific tasks in support of these missions are in the areas of flight systems development isotope fuels, power systems technology and support and space power systems safety. NASA will reimburse DOE for the flight generator. Also, discussions are underway for NASA to reimburse DOE for the qualification generator and the space flight generator. The DOE/NASA activities will continue to be conducted at the Lewis Research Center and the Jet Propulsion Laboratory.

Defense Programs, Office of International Security Affairs, has a joint effort (TIROS Satellite Project) ongoing with NASA and the National Oceanic and Atmospheric Administration (NOAA). Two specific Memoranda of Understanding among NOAA, NASA and DOE have been prepared for specific tasks associated with this TIROS Satellite effort.

Attachment C lists the DOE organizations and the specific NASA Centers where DOE-sponsored work is performed.

CONCLUSION

The DOE/NASA reimbursable efforts, which were formalized under the 1979 Memorandum of Understanding, have been and continue to be highly productive. DOE intends as appropriate, to continue to utilize NASA's expertise in its research and development programs. Accordingly, both organizations will continue to identify program tasks which will assure that DOE and NASA expertise continues to be applied to appropriate aspects of the agencies' respective missions.

ATTACHMENT A.—NASA/DOE PROGRAM CORRDINATION COMMITTEE

NASA MEMBERS

Hans Mark, Deputy Administrator, Co-Chairman.
Robert F. Allnutt, Acting Associate Administrator for External Affairs.
Walter Olstad, Associate Administrator for Management.
Jack L. Kerrebrock, Associate Administrator, Aeronautics and Space Technology.
Donald A. Beattie, Director, Energy Systems Division.

MECHTHILD PETERSON, NASA EXECUTIVE CO-SECRETARY

Guy W. Fiske, Under Secretary, Co-Chairman.
Joseph Tribble, Assistant Secretary for Conservation and Renewable Energy.
Shelby Brewer, Assistant Secretary for Nuclear Energy.
Jan Mares, Assistant Secretary for Fossil Energy.
Barbara McKee, DOE Executive Co-Secretary.

ATTACHMENT B.—DOE/NASA COOPERATIVE WORK, FISCAL YEAR 1982–83 FUNDING CHART

[In millions of dollars]

	Budget authority	
	Estimated, fiscal year 1982	Proposed, fiscal year 1983
Conservation and renewable energy: [1]		
Conservation:		
Vehicle and engine R. & D	36.2	3.1
Energy systems (storage, conversion and electric energy systems)	2.0	0
Renewable energy:		
Wind energy technology	22.9	3.4
Photovoltaic energy technology	23.0	6.0
Solar thermal energy technology	5.2	0
Biomass energy technology	.3	.3
Geothermal energy technology	.1	.1
Subtotal	89.7	12.9
Fossil energy: [1]		
Mining research and development	1.0	0
Heat engines	.6	0
Fuel cells	.6	0
Magnetohydrodynamics	1.4	0
Instrumentation and control	.6	0
Total	11.9	0
Energy research: Environmental R. & D	.8	.6
Nuclear energy:		
Space applications	33.9	29.3
Waste management (space option)	.1	.06
Subtotal	34.0	29.4

ATTACHMENT B.—DOE/NASA COOPERATIVE WORK, FISCAL YEAR 1982–83 FUNDING CHART—Continued

[In millions of dollars]

	Budget authority	
	Estimated, fiscal year 1982	Proposed, fiscal year 1983
Defense programs: Satellite project	1.3	.9
Total	137.7	43.8

[1] DOE-funded, NASA-managed activities only. These numbers reflect only the portion of each DOE program budget that is expended on reimbursable work with NASA, thus they do not represent the total program budget.

ATTACHMENT C.—NASA FIELD CENTERS PERFORMING WORK FOR DOE PROGRAMS

	DOE organizations	NASA field centers
Vehicle and engine R. & D	Office of Vehicle and Engine R. & D	Jet Propulsion Laboratory, Lewis Research Center.
Energy systems	Office of Energy Systems Research	Jet Propulsion Laboratory, Lewis Research Center.
Wind energy technology	Office of Solar Electric Technologies	Lewis Research Center.
Photovoltaic energy technology	Office of Solar Electric Technologies	Jet Propulsion Laboratory, Lewis Research Center.
Solar thermal energy technology	Office of Solar Heat Technologies	Jet Propulsion Laboratory.
Biomass energy technology	Office of Renewable Technology	Jet Propulsion Laboratory.
Geothermal energy technology	Office of Renewable Technology	Jet Propulsion Laboratory.
Mining research and development	Division of Fossil Fuel Extraction [1]	Jet Propulsion Laboratory.
Heat engines and heat recovery	Division of Combusion and Heat Engines [1]	Lewis Research Center.
Fuel cells	Division of Fuel Cells [1]	Lewis Research Center.
Instrumentation, control and diagnostics	Office of Advanced Research and Technology.	Jet Propulsion Laboratory.
Environmental reserach and development	Office of Health and Environmental Research.	Johnson Space Center, Langley Research Center.
Nuclear waste [2]	Office of Waste Isolation	Marshall Space Flight Center.

[1] Office of Coal Utilization and Extraction.

[2] $60,000 was authorized for the space disposal of radioactive waste activity through the first quarter of fiscal year 1982, at which time a decision was made to discontinue this effort.

STATEMENT OF HON. JAMES G. WATT, SECRETARY OF THE INTERIOR

INTRODUCTION

The Department of the Interior has the primary responsibility for managing the resources of the Nation's public lands and for maintaining a balance between multiple-purpose use and conservation of natural resources on these lands. Effective resource management and research require accurate timely data, whether collected on the ground, from high- or low-altitude aircraft, or by satellites. The Department employes aircraft to acquire photographs and carry experimental instruments to execute programs such as topographic mapping, land use mapping, cadastral surveys, and resource inventories.

The need for surveying and repetitively monitoring vast and often inaccessible areas has fostered a growing reliance on data acquired by satellite, primarily Landsat, because of its synoptic, repetitive, and uniform coverage. Digital Landsat data and sophisticated computerized techniques provide resource managers with flexibility in aggregating and integrating large amounts of Landsat information with other types of essential data.

Bureaus and agencies of the Department of the Interior involved in remote sensing studies during 1981 included the Bureau of Land Management (BLM), Bureau of Mines, Bureau of Reclamation, National Park Service, Office of Surface Mining Reclamation and Enforcement, U.S. Fish and Wildlife Service, and the U.S. Geological Survey. Other Federal agencies involved with the Department in these studies include the National Aeronautics and Space Administration (NASA), U.S. Army Corps of Engineers, U.S. Forest Service and Soil Conservation Service of the Department of Agriculture, and the Mine Safety and Health Administration of the Department of Labor.

EARTH RESOURCES OBSERVATION SYSTEMS OFFICE

The Earth Resources Observation Systems (EROS) Office, which was established in 1966 by order of the Under Secretary and is administered for the Department by the U.S. Geological Survey, is the focal point for most of the Department's Earth resource-oriented space activities. The purpose of the EROS Office is to develop, demonstrate, and encourage applications of aerospace technology to the resource and environmental inventory and management responsibilities of the Department of the Interior.

EROS personnel coordinate with representatives of Departmental bureaus and offices and jointly sponsor new applications of remote sensing technology. Much of this work has been made possible by the satellite data acquisition systems of NASA, such as Landsats 1, 2, and 3; Magsat; Seasat; Heat Capacity Mapping Mission (HCMM); and the space shuttle; and the aerial remote sensing research program. Other research draws from complementary data collection systems, such as the National Oceanic and Atmospheric Administration (NOAA) weather satellites, and from aircraft with remote sensing capabilities of other Federal and State agencies.

The fiscal year 1982 appropriation for the EROS Office is $11,904,000. The requested fiscal year 1983 budget is $9,490,000. Cooperative projects jointly funded by EROS and other Department of Interior Bureaus, Federal or State Agencies include such activities as land cover and terrain mapping. Under the Alaska National Interest Lands Conservation Act (ANILCA, P.L. 96-487, 1980), comprehensive conservation plans are mandated for each wildlife refuge in Alaska. The Alaska Department of Natural Resources, together with the U.S. Fish and Wildlife Service and EROS Office, began using Landsat data in this endeavor in fiscal year 1981 with a combined budget of $100,000. This level of activity will be continued in fiscal year 1982. Similar land cover and terrain maps are being made with the Bureau of Land Management for oil and gas lease areas in the National Petroleum Reserve, Alaska. Combined funding levels for fiscal year 1981 and 1982 are $16,000 each year. BLM with EROS is also conducting basic research using Landsat data for soil and vegetation inventories. Approximately $100,000 was expended in fiscal year 1981, and $40,000 is budgeted for fiscal year 1982. Bureau of Indian Affairs and EROS are spending $50,000 in fiscal year 1981 and $70,000 in fiscal year 1982 to determine irrigation potential on reservation lands.

NASA has directly funded EROS for some investigations such as evaluations, interpretation, and application of NASA's Magsat data. Funding for this activity was $51,000 in fiscal year 1981, and will be approximately $20,000 in fiscal year 1982. Another NASA cooperative project is the preparation of an "Illustrated Geomorphic Classification of Icelandic Volcanoes," which was funded at approximately $40,000 each year fo fiscal year 1981 and fiscal year 1982. The USGS planetary studies program is entirely funded by NASA.

In addition, space-related remote sensing activities are now conducted routinely in many research and management functions of the Department, but these activities are so closely integrated with conventional approaches that accurate identification of specific amounts and their correlation with the President's budget are not possible. However, remote sensing activities funded by Departmental bureaus are estimated to total about $2,000,000 in fiscal year 1982.

The three main functions of the EROS Office are: (1) data production, archiving, and dissemination, (2) user training and assistance, and (3) research and applications demonstration of uses of satellite and aerial data.

Data production and dissemination

The EROS Data Center (EDC), in Sioux Falls, S. Dak., is an archive for NASA's Landsat imagery, aerial photographs acquired by the Department of Interior, and photographs and imagery acquired by NASA from research aircraft and from manned spacecraft. A central computer complex provides access to a data base that contains more than 7 million images and photographs of the Earth's surface, searches for and identifies imagery of specific geographic areas of interest, and serves as a management tool for the entire data archival, reproduction, and dissemination process. Data archived at EDC at the end of fiscal year 1981 totaled about 1,645,000 items of Landsat imagery; 63,000 items of Gemini, Apollo, and Skylab imagery; and 5,070,000 aerial photographs. By the end of fiscal year 1982, the data archived at

EDC will include an estimated 1,815,000 items of Landsat imagery and more than 5,225,000 aerial photographs.

User demand for satellite and aircraft data has grown from 165,000 frames and 10 computer compatible tapes (CCT's) in fiscal year 1973 to 390,000 frames and 4,300 CCT's in fiscal year 1981. Demand is expected to remain about the same in fiscal year 1982.

A digital image processing system (EDIPS) was placed into service in fiscal year 1979 to produce higher quality Landsat images. This system performs production image processing on digital Landsat data provided by NASA. The system has been modified to accept partially corrected data from Goddard Space Flight Center and to make geometric corrections by resampling the data used for master reproducible film and digital products. This modification was fully operational in 1981. NASA is providing $30,000 in fiscal year 1982 for continued mocrofilming of pre-EDIPS data.

User training and assistance

One of the EROS Office objectives is to transfer to the user community, information pertaining to remote sensing and its applications to resource inventory and management. To this end, the staff conducts a program of training courses and workshops, prepares and disseminates workshop exercises, acts as a focal point for users' inquiries, and operates the Don L. Kulow Memorial Library at the EROS Data Center.

The EROS Office staff presented or contributed to 26 remote sensing training courses attended by over 470 persons in fiscal year 1981. Among the Department of the Interior agencies represented at these courses were the USGS Water Resources, Conservation, and Geologic Divisions, the Bureau of Land Management, the U.S. Fish and Wildlife Service, the Office of Surface Mining, and the Bureau of Reclamation.

The training courses ranged from 3 days to 4 weeks in length, and varied in content from fundamental of remote sensing applications to advanced digital image analysis techniques. In general, the courses were designed to serve the needs of both managers of natural resources and scientists for whom remote sensing can be a valuable information-gathering and analysis tool. EDC has scheduled 20 training courses in fiscal year 1982.

During the past year, 3 courses were offered to a total of 58 international scientists and resource managers. Two of the workshops were in the International Workshop series, regularly offered each May and September, and one was conducted in Buenos Aires, Argentina, under the sponsorship of the Organization of American States. A cooperative training program of the EROS Data Center and the Remote Sensing Institute at the South Dakota State University provided four remote sensing scientists from Argentina with practical training in the use of satellite data for forecasting agricultural crop production.

In addition, EROS completed a grant program totaling $250,000 to universities for the development of training materials and curriculums in remote sensing applications. Subject areas addressed include geology, forestry, agriculture, soils, strip mine monitoring, and archaeology. The objective of the grant program was to encourage universities possessing specialized expertise to become more active in providing remote sensing training to resource professionals through extension or continuing education programs.

An important adjunct to formal training courses is the Data Analysis Laboratory, which has become a focal point for developing and demonstrating computer-assisted image analysis techniques. The Data Analysis Laboratory, equipped with interactive computer systems, is recognized as one of the finest facilities in the world for the analysis of digitally processed imagery. It is heavily utilized by Interior Bureaus for research and operational project activities.

Prototype models of a remote image processing station (RIPS) have been designed by EROS to extend the use of Landsat and other remotely sensed data to field offices of the Department of the Interior. RIPS is not intended to compete with large minicomputer-based interactive systems, but to complement them through remote access to central computational resources. Image processing software has been written to handle routine analysis functions. RIPS will be able to input and analyze several sources of geographically referenced image data such as meteorological, Landsat, and topographic, as well as polygonal cartographic data structures.

A RIPS workshop was held in Sioux Falls, S. Dak., during fiscal year 1981 to provide a form for discussing concepts and sharing innovative ideas on microprocessors, other hardware devices, and accompanying software, as well as suggestions for system specifications. The workshop brought together potential users of RIPS technology with industry representatives, who might eventually be the providers of equipment, and demonstrated that the technology now exists to fulfill the RIPS concept of low-cost image processing capabilities.

Research and applications demonstration

During fiscal year 1982 and prior fiscal years, research has emphasized evaluating the potential contributions and applications of aerospace technology, particularly Landsat, to resource management and the scientific missions of the Department. In addition, research was performed to identify and foster uses of data from satellite systems other than Landsat multispectral scanner (MSS); for example, the HCMM thermal infrared radiometer, the Magsat magnetometer, and the Seasat 1 synthetic aperture radar and radar altimeter and also from side-looking airborne radar (SLAR). A bibliography of research reports published by the EROS Office in 1981 is included as Appendix I.

Examples of routine and some near-routine research and applications include:

TABLE 1.—ROUTINE USE

Mapping geologic structure for fuels and mineral exploration and for hazards assessment.
Inventorying surface waters.
Inventorying wetlands to assess the amount and type of waterfowl habitat and the impact of irrigation.
Surveying regions for the preparation of environmental impact statements.
Contributing information for the selection of utility corridors.
Mapping land cover in Alaska.
Mapping wildlife habitats on a regional basis.
Contributing to a National land use and land cover mapping program.
Monitoring weather.

TABLE 2.—NEAR-ROUTINE USE

Identifying potentially mineralized zones and altered areas.
Detecting and monitoring surface mining and mine reclamation.
Detecting land use and land cover change and making projections of, for example, suitability of land for irrigation development.
Mapping forest fuels for fire control.
Taking a crop census to determine water use.
Publishing image maps of unmapped or poorly mapped regions of Antarctica and other regions at 1:250,000, 1:500,000, and 1:1,000,000 scales in support of National and international cooperative programs.
"Quick response" mapping of flooded areas.

Application studies and demonstrations to be continued or completed in fiscal year 1982 include: (1) evaluation of multispectral infrared radiometer and radar data acquired by the space shuttle; (2) geologic and cartographic applications of SLAR data; (3) Landsat D thematic mapper investigations; (4) development in cooperation with the Office of Surface Mining of techniques for routine systematic monitoring of strip mine change using Landsat data; (5) study of luminescence as a means for identifying a variety of natural and manmade materials such as phosphate rock, oil seeps and spills, stressed vegetation, and industrial pollutants; (6) development of techniques for using Landsat data to monitor in arid regions land changes caused by climatic change or man's activities; (7) mapping drainage basin characteristics and monitoring water quality of reservoirs; (8) land cover and terrain mapping in Alaska; and (9) compilation of an atlas of Landsat images of the glaciers of the world.

EROS Alaska field office

The EROS Field Office located in Anchorage, Alaska, has been in operation for 2 years. With a full-time staff of six specialists and a complete capability for both image and data analysis, this office provides critically needed analytical services to both Alaska and Federal agencies who are using remotely sensed data to support the implementation of the Alaska native lands legislation. Cooperative projects conducted in fiscal year 1981 included:

Land cover classification of the coastal management zone around Bristol Bay, with Alaska Department of Natural Resources.

Environmental assessment of the North Slope, with U.S. Bureau of Land Management.

Digital land cover classification of the Seaward Peninsula, with U.S. Soil Conservation Service.

Vegetation inventory of the Tanana River Basin, for national resource inventory, with the U.S. Forest Service.

The Alaskan Field Office also conducts formal training courses in response to bureau and agency requests. In fiscal year 1981, five courses were conducted.

EXAMPLES OF CURRENT USES OF REMOTE SENSING TECHNOLOGY

The ability of the Department to include remote sensing and other advanced technologies in its normal operations can be attributed to the continuing progression from basic research, to applications demonstration, and then to routine utilization by the bureaus.

Examples of some current uses of aerospace technology in the exploration for and management of specific natural resources are described below.

FUELS AND MINERALS

Lithologic discrimination

Studies to improve discrimination of lithologic variations in sedimentary rocks and detection of surficial effects related to subsurface hydrocarbon occurrences using remotely-sensed data are being conducted in the Uinta and Piceance sedimentary basins of northeastern Utah and northwestern Colorado. Initial results show that Landsat multispectral scanner (MSS) and thematic mapper simulator (TMS) data, acquired by NASA/NSTL for selected areas in the region, can be digitally processed to enhance separation of lithologic variation. Ground spectral data (760-bands between 0.40 and 2.50 μm), collected from more than 200 localities within the TMS coverage areas, and 760-band aerial spectral data are being used to help design optimal digital processing approaches, as well as to calibrate TMS data.

Landsat MSS and TMS data have been registered to a Universal Transverse Mercator map base and will be used with similarly registered topographic, aeromagnetic, gravity, and geochemical data to develop and evaluate models and techniques for applying multiple data sets to the problem of rapidly, economically, and accurately defining exploration target areas that have a high potential for the occurrence of petroleum.

Monitoring energy resource development

Landsat 3 return beam vidicon (RBV) images acquired on October 15, 1978, over Hobbs, New Mexico, were compared to the 1976 Geologic Atlas of Texas, Hobbs Sheet, and the corresponding USGS topographic map to monitor the growth of oil and gas fields in the region over a 2-year period. On the 1° X 2°, 1:250,000-scale, USGS topographic map of Hobbs, New Mexico, 1,339 oil and gas wells are shown in an area 85 by 67 km. On the RBV image, an additional 3,365 oil and gas wells, mostly offset development drill holes, were identified in the same area, an increase in the number of oil and gas wells of 250 percent. The availability of Landsat 3 RBV imagery provides scientists and energy resource managers with a data base for accurate assessment and monitoring of exploration for and development of hydrocarbon resources. RBV imagery can serve as a planimetric base to identify areas of change in active oil and gas fields, thus limiting the need for expensive low-altitude aircraft flying programs.

Data base development and resource modeling

The EROS Data Center developed a digital geologic data base for part of the Nabesna topographic quadrangle, Alaska, to develop and test a geologic model for evaluating porphyry copper potential in the area. The data base incorporated Landsat MSS data, Defense Mapping Agency (DMA) topographic data, and Alaskan Mineral Resources Assessment Program (AMRAP) data sets, including residual aeromagnetic data, Bouguer gravity data, stream sediment geochemical data (for copper, lead, gold, chromium, and cobalt content), geologic data, mineral occurrence data, and land use data. All data were digitized into a common format, interpolated to generate continuous data arrays, resampled, and geographically registered. Field studies were then conducted in areas that the model identified as having high mineral potential. Rock samples from Orange Hill, Bond Creek, Cross Creek, Horsfeld Creek, and Baultoff Creek areas were collected for geochemical analysis to confirm the results of the digital data base analyses. All areas indicated by the model as having high potential for copper mineralization were found to be intensely altered, an indication of potential mineralization.

Lineament analysis and strategic mineral resources

Research continued on strategic mineral resources of the United States. Mineral deposits were plotted by commodity on a separate 1:5,000,000-scale lineament map base, and the locations were compared to local lineament trends to define possible exploration targets. Landsat index maps were compiled for each strategic mineral by State to facilitate data searches by mining geologists. Nine mining districts were selected for analysis and include Franklin Furnace, New Jersey (lead, zinc), Adirondacks, N.Y. (iron), Mesabi Range, Minn. (iron), Homestake, South Dakota (gold), Butte, Anaconda, Mont. (copper), Ajo, Arizona (copper), Bingham Canyon, Utah (copper), Climax, Colorado (molybdenum), and the Missouri Lead belt. Topographic and geologic maps, and Landsat RBV and MSS images of the mining areas were compiled, and overlays were produced to define known structure as well as observed lineaments. Computer processing (linear stretches, low- and high-pass filters, lineament enhancements and extractions) of images for the Mesabi and Bingham Districts enhanced interpretation.

Evaluation of satellite imaging systems for geologic applications

To assess the usefulness of heat Capacity Mapping Mission (HCMM) and Seasat Synthetic Aperture Radar (SAR) data for geologic applications, analyses were made of HCMM day-visible (0.55–1.1 μm) and day-thermal infrared (10.5–12.5 μm) data of the southwest United States. Differences in responses due to the physical properties of surficial materials—specifically vegetation, soil mositure, rock types and structural features—were observed in the visible and infrared response regions. CCT's of the same region were enhanced for geologic interpretation. High-pass filters and diagonal derivative images accentuated the linear components of the data. Lineaments on the thermal infrared data appear to be related to differences in ground materials and mositure concentration.

Seasat SAR images acquired July 23, 1978, of an area from Lake Erie to Cape Hatteras, N. C., were evaluated for geologic application uses. The SAR is an L-band (23.5-μm wavelength) system with 25-m resolution. The 100-km-wide image swath was produced on a southeast-to-northwest ascending satellite node with a look direction of N67.5°E. The look direction and look angle (20.5° off vertical) enhanced the cross strike structures of the northeast-trending Applachian Mountains.

The SAR data available include data on the major physiographic provinces of the Eastern United states specifically, the Cumberland Plateau, Valley and Ridge (Appalachians), Blue Ridge Mountains, Culpeper Basin, Pidemont, and the Coastal Plain. Shale of Ordovician age was differentiated from Ordovician dolomite on the basis of drainage variations in the Shenandoah Valley. Resistant chert formations that form prominent topographic remnants could be identified on SAR even though they were undectable on Landsat. Topography, structure, drainage patterns, and vegetation differences were accentuated on the SAR images and can be used as a complementary data base for geologic investigations.

International cooperation in fuels and minerals exploration

The signing by the USGS and the People's Republic of China of Annex 1 to the Protocol for Scientific and Technological Exchange in the Earth Sciences has resulted in renewed activity on Project 2A, Application of Remote Sensing techniques to petroleum Exploration. Geologists from EROS Data Center and the Scientific Research Institute for Petroleum Exploration and Development of China's Ministry of Petroleum Industry are working on a geologic interpretation of Landsat imagery for the entire Chaidamu Basin of western China. Various digital processing techniques are being applied to Landsat data from selected areas of the basin to define those techniques which optimize interpretation of geologic information. During the summer of 1982, Chinese scientists will visit the EROS Data Center for 2 months, and the two groups will jointly review and evaluate the work done independently by each group. The Chinese scientists will also bring with them various ancillary data on the Chaidamu Basin. An analysis strategy will be developed to integrate these data with Landsat data in a multiple data set to evaluate the petroleum exploration potential of the Chaidamu Basin and, conversely, to evaluate the effectiveness of using the multiple data set for this area. The joint review will apply results obtained by EROS Data Center scientists for the geologically similar Uinta Basin, Utah.

Under the International Geologic Correlation Programme of the International Union of Geological Sciences since 1975, the USGS has provided leadership in bringing together those geologists interested in applying remote sensing techniques to mineral exploration programs. The project will conclude in May 1982 with a special international symposium as part of the Committee on Space Research meeting in

Ottawa, Canada. The results of the project, providing case histories from around the world, will be published. More than 300 scientists from more than 80 countries have participated. Landsat has been the principal source of data in the project. Other data sources such as Meteror, Soyuz, Appollo, Skylab, Seasat, Magsat, POGO, and HCMM have also been used to a lesser extent. A bibliography of over 2,000 references on this subject has been developed and distributed. National mosaics and lineament maps have been developed in most participating countries, and these have served as a base on which to plot mineral localities that, in turn, serve as guides to exploration for new deposits.

WATER MANAGEMENT

Irrigation analysis

In cooperation with the U.S. Army Corps of Engineers, Portland District, the USGS developed and tested techniques using combiantions of Landsat and geographic data to evaluate irrigation agriculture in the 6,500-km² Umatilla River Basin in north-central Oregon. Landsat data were manually interpreted to map the growth of irrigation from 1973 to 1979, and then were digitally analyzed to identify crop types under irrigation in 1979. The crop data were used with historical agricultural data and digitized topographic and hydrographic data to estimate water and power use for the 1979 irrigation season. A composite map of land suitability for irrigation development was produced from Landsat-derived land cover information and landownership, soil irrigability, slope gradient, and potential energy-cost data.

The USGS continued investigations in the High Plains area covering parts of eight States. Methods for mapping irrigated cropland by digital analysis of Landsat data were evaluated, and maps were used to estimate ground-water withdrawals. Ratioing of multitemporal data provided the best approach to mapping irrigated cropland. A total of 59 Landsat scenes were ratioed and aggregated for input to a digital model of the Ogallala aquifer, the main ground-water-bearing formation undelying the High Plains. The data will be used to calculate the total amount of water pumped form the aquifer for irrigation.

In a cooperative project with the Bureau of Indian Affairs (BIA) Office at Aberdeen, South Dakota, the USGS developed a multiple digital data base for the Lower Brule and Crow Creek Indian Reservations. The data base was used to determine the potential for irrigated agriculture on the reservation lands and to assist in resource management. The project resulted in maps showing irrigation potential and in other types of information usable in the resource management decision process of the BIA.

Basin characteristics

Multiple spatial data sets have been complied into a hydrologic information system for the Black Hills area of South Dakota. This work is being done by EROS in cooperation with the South Dakota District Office, Water Resources Division. The objective is to derive stream basin characteristics for calculations of runoff, ground-water recharge, and a water budget. The data sets include Landsat images, digital topographic, land cover, geologic, basin drainage and boundary data sets, and precipitation and streamflow indices. Data set formatting and parameter evalaution were completed, and research on the calculation of surface drainage areas and the automated delineation of drainage lines from digital topographic data was begun.

MONITORING THE ENVIRONMENT

Soil/vegetation inventory

The Bureau of Land Management is responsible for approximately 100 million hm² of arid and semi-arid public lands in the western United States. The Federal Land Policy and Management Act of 1976 requires current resource inventories to be maintained on public lands. Because the cost of inventorying soil and vegetation resources has escalated rapidly, the amount of land that can be inventoried each year by conventional methods is severely constrained.

In fiscal year 1981, USGS and BLM initiated a cooperative project to investigate the potential of using Landsat MSS data and other digital data for mapping ecologically significant soil/vegetation landscapes called site wrap-up areas. A digital data base was assembled for the Grass Creek Resource Area (594,000 hm²), Worland District, in north-central Wyoming. Landsat MSS data from June 1978, soils boundaries, digital terrain data, and digitized administrative boundaries were registered to a common 50-meter UTM grid base.

The Landsat data were stratified and spectral classes were aggregated to represent 21 plant community types. The 21-class vegetation digital map and digitized soil and allotment boundaries were used to delineate and map ecologically significant soil/vegetation landscapes. The resulting vegetation group classes were subsequently mapped within soils boundaries and 1:24,000-scale transparent overlays were produced for 7.5-minute topographic maps. Both manual and digital methods were evaluated for producing the final site write-up area maps.

Although a final evaluation remains to be completed by the BLM, a preliminary field evaluation of the products supports the following conclusions:

(1) The concept of using digital soils data and vegetation information derived from Landsat MSS data for mapping ecologically significant soil/vegetation landscapes is verified.

(2) Misclassification of vegetation present, caused primarily by variations in the amount of ground cover within plant community types, did not adversely affect site write-up area delineation.

(3) Maps of ecologically important soil/vegetation landscapes can be produced for less than $0.20 per hm². The resulting digital data base also forms an important information source for post-inventory land management activities.

Accuracy assessment of Landsat-derived Arizona wildland vegetation map

In fiscal year 1980, USGS and Bureau of Land Management personnel completed a cooperative demonstration project in Mojave County, Arizona. The objective was to determine the usefulness of Landsat data, combined with conventional aerial photography and data from ground surveys, for mapping and inventorying wildland vegetation. During fiscal year 1981, the accuracy of the vegetation map was evaluated.

A cost-effective sampling design was developed, and classification accuracy was estimated by comparison of photo-interpretation classification with the corresponding Landsat digital classification. Ground data were obtained to refine the accuracy estimate. Overall vegetation map accuracy was estimated to be 64 percent with a standard error of 2 percent.

Improving Landsat classification and managing a forested wetland

Recent research has demonstrated that Landsat classification results are improved by incorporating ancillary data. Multiple data sets, when registered to a common map base, can be manipulated using Geographic Information System (GIS) techniques.

USGS develop a digital data base for the Great Dismal Swamp of Virginia by registering January 1978 Landsat data, photo-interpreted vegetation classes, ground surface elevations, organic soil (peat) depths, and road, ditch, and refuge boundary locations to a common map projection (50-m UTM grid). The resulting thematic maps are being used in the improvement of wood-duck habitat and in the control of the eastern forest tent caterpillar. As additional layers of information were added to the data base, the refuge managers began to realize fully its potential for providing decisionmaking information quickly and economically.

Land cover and terrain mapping in Alaska

The EROS Alaska Field Office has used Landsat MSS data to classify over 1 million hm² of land cover within the Kenai National Wildlife Refuge. The Alaska Department of Natural Resources (ADNR) and the U.S. Fish and Wildlife Service (USF&WS) have used the computer analysis equipment of the EROS Alaska Field Office to produce land cover and terrain maps of the Bristol Bay Subregion, an area of approximately 12 million hm² including all or parts of the Togiak, Izembek, Alaska Peninsula, and Becharof National Wildlife Refuges. Digital terrain data from the 1:250,000-scale USGS topgraphic maps were registered to the Landsat data to produce elevation, slope, and aspect maps. The terrain data on elevation and slope improved classification accuracy of the land cover maps. In the Bristol Bay Subregion, winter Landsat scenes were extremely useful for clearly separating wetland from conifer cover types. For the Kenai Wildlife Refuge, the land cover and terrain data were combined with data on surficial geology to form a multiple data base and produce resource maps from each data type and from combinations of each data type. The land cover and resources maps were used by ADNR and USF&WS for comprehensive planning, as mandated by the Alaska National Interest Lands Conservation Act of 1980.

The U.S. Forest Service has worked cooperatively with the EROS Alaska Field Office to develop sampling techniques for inventory of vegetation resources in Alaska. Digital land cover classifications from Landsat MSS data combined with sampling of vegetation type from high- and low-altitude aerial photographs and ground sample plots reduces sampling error. Preliminary results from Landsat land cover classifications of 130 hm² sample plots in the Susitna River Basin were favorable, thereby setting the stage for an operational test of methodologies in the Western half of the Tanana River Basin during fiscal year 1982.

The USGS used Landsat digital data to map land cover in the National Petroleum Reserve area in Alaska. Efforts in 1981 included mapping of the Prudhoe Bay Region and, in cooperation with the U.S. Fish and Wildlife Service, the Arctic National Wildlife Refuge. Preliminary products of the digital analyses of land cover were provided to cooperating agencies. The BLM used these data with digital terrain data to assess potential impacts of lease sales.

Land cover mapping with merged Landsat RBV and MSS stereoscopc images

The USGS with Lockheed Missiles and Space Company demonstrated that the interpretability of current Landsat data can be improved considerably when presented to the image analyst as stereoscopic, color-composite images (three spectral channels) at a ground resolution of approximately 40 meters. Interpretations of vegetation types, densities, canopy characteristics, and boundaries were improved when using a merged RBV and MSS stereoscopic image compared to using the MSS or RBV image alone. However, images with a resolution greater than 40 meters are needed to consistently detect and identify canopy characteristics related to forest stand structure. The location of, and association between, vegetative features and topography were readily seen on the RBV/MSS stereoscopic pair. Analysis of the RBV image alone produced results on vegetation type and boundary placement nearly as good as results derived from analysis of the merged RBV/MSS image.

The results of this work suggest that data acquired from the proposed Mapsat sensors, the planned Thematic Mapper on Landsat D, the High-Resolution Visible imaging instrument on the French SPOT (Systeme Probatoire d'Observation de la Terre) Satellite, and the Large Format Camera on the space shuttle will allow improvements in classifications of forestlands, using visual interpretation techniques, as compared to classifications from data currently available from Landsats 1, 2, and 3.

Geographic analysis

EROS conducted a geographic analysis of the Sioux Falls area in cooperation with various Sioux Falls, South Dakota, area planning agencies. The overall goal was to demonstrate the application of remote sensing and geographic data base tehniques to planning problems in the Sioux Falls area. The specific objectives were: (1) to inventory rural land use by aerial photograph interpretation, (2) to develop a digital geographic data base consisting of land use, soils, and slope data, and (3) to generate maps and statistics describing physical limitations of rural land to development.

Sioux Falls area planners interpreted USGS land use categories on color-infrared 1:24,000-scale aerial photographs. The interpretations were digitized at the EROS Data Center, registered to the UTM coordinate system, and converted to digital images consisting of 50- by 50-m grid cells. Similarly, digitized soil and slope data were input to the data base. Soils data were acquired from Soil Conservation Service county soil surveys. Slope data were derived from Defense Mapping Agency digital elevation tapes acquired from the National Cartographic Information Center, U.S. Geological Survey.

The land use, soils, and slope digital data were composited to produce images and statistics describing the limitations of rural land for septic tank operation, dwelling unit construction, road and street construction, and agriculture. The products are being used by Sioux Falls area planners to formulate long-term plans.

CARTOGRAPHY

Landsat image maps

Analysis of the geometry, resolution, and radiometric quantities of Landsat 3 return beam vidicon (RBV) imagery confirmed their suitability for image map preparation at scales as large as 1:100,000. Tests indicate that one of the most common radiometric anomalies found in the standard RBV images, shading, can for the most part be removed by relatively simply analog processing.

New methods and techniques were developed for processing Landsat data to cartographic form as the result of experimental image map compilation. Experimental image maps of Cape Cod, Mass., and Ikpikpuk River, Alaska, were prepared at scales of 1:100,000 and 1:250,000. In response to requests for technical assistance, image maps of areas in Saudi Arabia, Pakistan, Antarctica, and Africa were prepared to demonstrate these new techniques. Both digital and analog techniques were used for enhancing the images. New techniques such as screenless printing were used for reproductions.

As a result of the distribution of the Landsat image map of the Berry Islands, The Bahamas, produced in cooperation with the Defense Mapping Agency from combined Landsat and hydrographic data, the value of MSS data for delineating shore lines and for mapping shallow seas has become widely known. Inquiries and requests for assistance from those concerned with island and shallow seas mapping programs have been received. During 1981 a new program was developed to map the extensive shallow seas north and east of the New Guinea island.

Geometric registration

In 1981, EROS conducted research and developed software and procedures for registration of temporal and multi-level image data sets and for registration of a Landsat image to a map base. These capabilities will provide users with a standard procedure to produce and utilize geometrically registered Landsat data products that can be easily integrated with other spatial data.

The approach to this project was to implement the following tasks in the order listed.

Define, contract, purchase, and install hardware.
Design system software.
Implement image-to-map registration.
Implement image-to-image registration.
Incorporate the Landsat ground control point library of the Goddard Space Flight Center.

Hardware has been installed. The system software has been designed and is being implemented. Image-to-map registration is nearly complete. Final enhancements are currently being made along with the documentation. The image-to-image automatic correlation software is under development and will be tested early in 1982. The incorporation of the Goddard ground control point library is still in the analysis stage, and will be accomplished following the implementation of image-to-image registration techniques.

Map revision

Characteristics of Landsat data such as timeliness of images, repeat cycle of 18 days, simple enlargements without rectification, and the broad coverage in a single image are advantageous for map revision. Experiments with RBV data have verified these advantages and have demonstrated that RBV imagery can be used to update specific features such as woodland, new highways, and streams on maps at scales up to at least 1:100,000 where conventional sources of revision data are absent.

Through contacts with the Canadian and Australian mapping agencies, it was also verified that Landsat MSS and RBV data have been successfully applied to the revision of 1:250,000 and smaller scale line maps on an operational basis. The Canadians have also utilized Landsat as an inspection tool for their 1:50,000-scale mapping program to determine which map quadrangles require revision and thus to indicate the necessary acquisition of new aerial photography. The implementation of this procedure has resulted in substantial savings, and the procedure is considered applicable to many other areas of the world.

Index map of Landsat images of Antarctica

The USGS is compiling a 1:5,000,000-scale "Index Map of Optimum Landsat Images of Antarctica." Approximately 2,500 Landsat scenes have been identified, and their quality assessed. Landsat has the potential for imaging about 79 percent of the area of Antarctica, and 70 percent of the Landsat imaging area, or about 55 percent of the continent, was found to be of excellent or good (less than 10 percent cloud cover) quality.

Available Landsat images could be used, in combination with doppler satellite technology for geodetic control, to triple the area of Antarctica currently mapped at scales of 1:250,000 or larger. Landsat 3 RBV images can also be used to prepare 1:100,000-scale image maps.

High-altitude aerial photography program

A program to acquire uniform, repetitive high-altitude aerial photography of the United States is administered by the USGS and funded by 12 additional Government agencies. Two aerial mapping cameras acquire high-resolution black-and-white (1:80,000-scale) and color-infrared (1:58,000-scale) photographs along flight lines that approximately follow the center lines of 7.5-minute quadrangles. Photographs are available to the public from the EROS Data Center, Sioux Falls, South Dakota, and from the Agricultural Stabilization and Conservation Service in Salt Lake City, Utah.

In 1980, the first year of operation, 81,000 frames of black-and-white and color-infrared photography were acquired. Through 1981, about 25 percent of the conterminous United States has been flown. The nationwide aerial photographic data base is currently scheduled for completion in 1985.

LONG-TERM RESEARCH

The objective of long term research is to add to our basic knowledge of the Earth. In some cases, this knowledge has direct and immediate application to the development of supplies of energy, minerals, water, food, and fiber, and to protection of the environment. In other cases, the knowledge is for scientific purposes, such as measurement of movements in the crust of the Earth or global measurements of the magnetic field and its change with time.

The acquisition of data by spacecraft has opened many new fields of study that would be impractical by any other approach. Both the meteorological satellites and the Earth resources satellites have demonstrated their capabilities for worldwide monitoring. Much more must be learned about meteorology and Earth resources, however, if we are to obtain the maximum benefit from our ability to use space. Other new areas of study exist for which experiments and ideas are only in their early stages of development.

Many additional measurement capabilities using satellites can be developed during the next few years that will greatly add to our ability to understand the Earth. The remainder of this testimony will adress current research on remote sensing systems for potential multidisciplinary applications. The topic coverage is intended to be representative rather than exhaustive. In addition, expanded discussions of each topic will become practical as research continues.

Magsat

With funding from NASA, EROS personnel conducted a preliminary analysis of global magnetic anomalies. The NASA Magsat satellite has provided the first worldwide geomagnetic data set of high, uniform standard. Together with information on known mineral deposits, these data may improve our understanding of resource origin, distribution, and regional potential.

Mapsat

After more than 10 years of study and experimentation, the USGS has conceptually defined a candidate Operational Earth Sensing Satellite Mapping System that combines stereoscopic coverage, improved resolution and geometry, and multispectral capability with simple, cost-effective operation. Multicolor image maps at scales as large as 1:50,000 with 20-m typographic conture intervals are one potential of the system. Results of a feasibility study conducted by the industrial team of Itek-TRW indicated that the Mapsat concept encompasses features that could make an operational satellite mapping system an economic and practical possibility and that the concept can be applied within limits of current state-of-the-art technology.

Seasat

In 1981 the USGS continued to jointly fund studies with NASA's Wallops Island Station to evaluate the land applications of the Seasat radar altimeter. The system has accurately determined evaluations in areas that are relatively flat. Tests over the Great Salt Lake Desert, Bonneville Salt Flats, have provided new elevation information at a detail not generally provided in standard mapping programs. Applications in areas of subsidence caused by ground water or petroleum withdrawal, such as the San Joaquin Valley, California; Eloy area, Arizona; and Houston, Texas, have been tested to an accuracy of 20 centimeters. The altimeter has also been tested over tropical regions such as the Florida Everglades, where detailed waveform studies have demonstrated that the radar response from the tops of trees and swamp grass can be accurately detected.

Seasat L-band synthetic aperture radar imagery has been used for discrimination of flooded wetland forest from other surrounding forest. Analysis was most effective in the nearly level areas of the Atlantic and Gulf Coastal Plains. Seasat digital data have been tested for geologic mapping in heavily vegetated areas. L-band radar imagery and the radar altimeter were also used in mapping snow and ice features and surface elevations of major ice sheets. These studies not only identified the applications of the abundant data acquired under the Seasat experiment, but also defined the parameters for a new radar altimeter that could be flown on a future stereomapping satellite.

Shuttle multispectral infrared radiometer (SMIRR)

NASA, the Jet Propulsion Laboratory, and USGS tested SMIRR on the space shuttle. This new multispectral device operates on 10 channels in the spectral region of 0.6 to 2.5 μm and is expected to provide data from which altered ground associated with mineral deposits can be detected much more effectively than it could be from previous spacecraft data. Initial tests of the instrument in aircraft flights over mineral districts, and of data from a similar instrument flown earlier, showed high accuracy in delineating altered ground representing fossil hydrothermal systems that had produced mineral deposits. The second flight of the shuttle *Columbia* was successful in recording 186 minutes of SMIRR data over desert regions of Mexico, Spain, Italy, Greece, Turkey, Morocco, Egypt, and Saudi Arabia. Unfortunately, test areas over the United States and Australia were covered by clouds. Spectral bands are being evaluated for geologic mapping purposes and as input to the design of future multispectral scanners.

Landsat D

The fourth spacecraft in the Landsat series of Earth-orbiting satellites, Landsat D, will be launched in 1982. It is designed primarily to acquire medium resolution (about 30 m in the visible and near infrared) multispectral images of the land and shallow water areas of the planet. The engineering configuration of Landsat D is markedly different from that of Landsats 1, 2, and 3. This satellite will provide improved spectral sensitivity, improved spatial resolution, and additional spectral bands that will help in identifying mineralized zones.

The additional spectral bands and the increased spatial resolution of the Thematic Mapper (TM) will also offer a number of research and programmatic advantages to complement the MSS data from the first three Landsat spacecraft, such as:

1. Increased accuracy in regional geological mapping of rock types because of two new spectral bands in the near infrared. More interspectral band-ratioing combinations will also be possible, thereby permitting better discrimination of certain rock types, especially those associated with hydrothermally altered mineralized zones.
2. Greater penetration of fresh and marine waters will permit improved hydrographic charting and planimetric and bathymetric mapping of shallow seas and offshore banks and areas of special interest in petroleum exploration.
3. Landsat image maps at scales of 1:250,000 will become possible.
4. More accurate land use and land cover maps of suburban and urban areas will become available. Rapid updates of existing land use and land cover maps will also become possible on a routine basis.

The EROS Data Center will evaluate the geodetic accuracy of both the MSS and TM data and processing systems performance.

APPENDIX I.—EARTH RESOURCES OBSERVATION SYSTEMS OFFICE, U.S. GEOLOGICAL SURVEY 1981 PUBLICATIONS

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STATEMENT OF CHARLES HORNER, DEPUTY ASSISTANT SECRETARY FOR SCIENCE AND TECHNOLOGY, BUREAU OF OCEANS AND INTERNATIONAL ENVIRONMENTAL AND SCIENTIFIC AFFAIRS, DEPARTMENT OF STATE

Mr. Chairman and members of the subcommittee, as requested in Senator Schmitt's letter of March 4, 1982, it is a pleasure to provide you an assessment of both our Nation's current international space and aeronautics programs and the implications for these activities of the fiscal years 1982 and 1983 budgetary decisions affecting the National Aeronautics and Space Administration.

While NASA's space and aeronautics activities are not in themselves designed for specific foreign policy purposes, their contributions to our foreign policy goals are nonetheless substantial. Our space program is perhaps the most highly visible and impressive demonstration of the scientific and technological capabilities of the United States. It underscores our leadership in the world, reinforces our reputation for technological excellence and almost certainly buttresses our position in the world's commerce in "high technology." The openness of our programs, moreover, is strong evidence of the self-confidence and competence of a free society.

Opportunities for international participation in our civil space program can also support other foreign policy objectives. Few nations have the capability to operate in space by themselves; access to our programs for qualified foreign partners permits them to share in important achievements that would be otherwise unavailable. This mutually beneficial cooperation strengthens many of our bilateral relationships. Countries who are not direct participants also have access to the results and benefits of many space applications programs, which adds a positive element to our relations with an even larger number of countries.

Since there is no budget "line item" for NASA's "international programs", support for such activity is provided through the funding of specific projects. In this regard, we feel that the budgetary proposals for NASA are generally adequate to support those international activities which further U.S. foreign policy goals.

Two programs which are supported in the existing budgetary proposals are of special significance. The first is the Galileo mission to Jupiter, scheduled for 1985. In addition to maintaining the U.S. lead in interplanetary exploration, this assures our ally, the Federal Republic of Germany, the continuation of a project in which it has already made a substantial investment. Secondly, funds are proposed to meet a significant part of our support for the International Solar Polar Mission (ISPM), a cooperative program with the European Space Agency whose scope was reduced this past year. A number of other programs described in the testimony of Kenneth Pedersen, Director of NASA's International Affairs Division, on March 18, 1982, contribute to these same large objectives.

Much of NASA's overall R&D program, even when carried out at home, still has significant foreign implications. The pioneering work done in satellite communications has led to a highly effective integrated global network. Advances in remote sensing have provided a powerful tool for the discovery and the development of natural resources in many countries. NASA's work in photovoltaics has worldwide potential for the effective utilization of solar energy, especially in developing countries. The Department of State is satisfied that the Administration's budget requests are adequate to maintain our momentum and leadership in such areas. And we look forward to UNISPACE-82, the United Nations Conference on the Exploration and Peaceful Uses of Outer Space, to be held in Vienna this August, as an important opportunity to evaluate the future status of all these efforts.

There are some things which are very real, yet hard to measure—the enthusiasm of millions around the world for our Space Shuttle flights. Moreover, the Shuttle is our most formidable way of providing access to space for the nations of the world. The Shuttle, in providing launch services and satellite retrieval services will surely have a revolutionary effect on the exploitation of space. Being the pioneer in the development of such technology is important to the economic and strategic position of our country.

Thus the Department of State regards the NASA program as a significant and constructive contribution to our foreign policy. Its extraordinary achievements—which have carried the fruits of American ingenuity out into the universe—continue to have a profound influence on our standing in the world.

STATEMENT OF THE EXECUTIVE COMMITTEE, DIVISION FOR PLANETARY SCIENCES, AMERICAN ASTRONOMICAL SOCIETY

The American program of planetary exploration has been one of the most productive scientific enterprises ever undertaken. At the cost of just a few percent of NASA's budget during the past decade, this program has brought not only a wealth of new understanding about our place in the solar system, but it has brought additionally worldwide respect for the excellence of American science and technology.

Now the Administration proposes to cut so deeply into the basic planetary research and operations budgets for fiscal year 1983 that the future of the enterprise is in jeopardy. The cuts would require turning off data transmissions from existing spacecraft, closure of unique facilities, and abrupt cancellation of grants to first-rate research groups engaged in analyzing the wealth of planetary data obtained in the 1970's. We believe that the minimal responsible action that Congress could take would be to restore $40 million of these cuts: $25 million to the Research and Analysis line item, and $15 million to the Mission Operations line item.

For several years, NASA's goals of extending our reconnaissance of the solar system and for following up on the exciting discoveries of the 1970's have been compromised by our failure to initiate new spacecraft missions. Thus, the exploration of Venus is being left to the Soviet Union alone. Also, a host of nations, but not including the United States, will be making deep-space measurements on one of the most famous objects in the heavens—Halley's Comet.

There remains only one deep-space mission in the queue, Project Galileo, which is scheduled for launch toward Jupiter in 1985. Other excellent missions have been proposed as candidates for Administration and Congressional approval, including a Venus mapper. Right now a series of low-cost missions is being designed to focus on outstanding questions about asteroids, comets, Mars, and the atmospheres of the outer planets. While the flight mission program is on hold, it is essential that the vitality of the base programs be retained. Instead, they have been budgeted on a going-out-of-business curve from their already pinched-back fiscal year 1981 levels. In that year, Research and Analysis and Mission Operations totalled $112.5 million. Now they are proposed to total just $62 million in fiscal year 1983. In fact, the critical damage has already begun since the first part of these cuts have already been implemented in fiscal year 1982.

EFFECTS OF THE CUTS

In level of effort, the cuts mean scrapping more than half of the base planetary programs over a 2-year interval, mostly to be implemented in fiscal year 1983. The specific impacts are detailed in the Appendix to this statement, but let us summarize them briefly here:

The basic program of planetary Research and Data Analysis supports telescopic observations, laboratory experiments, and theoretical research in planetary science. It supports the bulk of the post-mission efforts to analyze and understand the pictures and other data sent back by the numerous missions of the 1970's. This includes study of moon rocks and the remarkable meteorites recently found in Antarctica. The program supports the world's finest infrared telescope, a high-velocity impact facility used to learn about planetary cratering processes, regional libraries and spacecraft pictures of the planets, and other unique laboratories and facilities.

The cutbacks in Research and Analysis would mean that a quarter of the chief scientists and research groups in universities, laboratories, and observatories around the country would lose their funding, disband, and cease their efforts to understand the planets. The NASA Infrared Telescope Facility in Hawaii would be closed. The Lunar Curatorial Facility in Houston would be placed on a subsistence budget, undermining laboratory research programs on moon rocks and meteorites. The minimal American effort to participate in the European mission to Halley's Comet would be further undermined.

The basic program of planetary Mission Operations and Analysis enables us to receive data transmissions from existing spacecraft like Pioneer Venus Orbiter, Voyagers 1 and 2, and Pioneers 10 and 11. All these spacecraft were expected to continue sending back invaluable data for many more years. Yet, the budget cuts will require that they be turned off permanently on January 1, 1983. The cutbacks also preclude most of the planned effort to open the brand new Voyager data on Saturn and Jupiter to analysis by the broader scientific community. Finally, the cutbacks undermine several scientific and engineering efforts to prepare for the Galileo mission and to design new, low-cost planetary missions for the future.

THE IMPORTANCE OF PLANETARY SCIENCE

Planetary research represents the epitome of American high technology being applied to address some of the most fundamental questions that face human beings: What conditions have led to the origin of life? What planetary processes are responsible for shaping the environments in which we live and for forming the raw materials that sustain civilization? How stable are planetary environments, including the surface of the Earth, against effects that might change them dangerously?

Planetary science is an area of basic research that will yield most of its payoff in the medium and long-term. But because it addresses the processes that affect planets like our own, it often results in surprising insights with immediate, practical benefits. For instance, studies of global topography of Mars, Venus and the Earth led to the discovery within the last year of a transcontinental fault that may be responsible for the largest earthquakes that occur in North America. Theoretical research concerning the atmosphere of Venus led to an appreciation of how our own ozone layer is affected by chemicals released by aerosol spray cans. Studies of river channels and polar deposits on Mars have led to a new understanding of the way the sun controls our climate and is responsible for ice ages. Discoveries of rare materials on some asteroids hold the promise for a future bonanza of mineral wealth in space. And, of course, the development of micro-electronic components and detectors for planetary spacecraft have filtered throughout the electronics industry.

REQUIRED ACTION

A revitalized American planetary exploration program will soon require a decision to initiate new spacecraft missions to the planets. These are necessary so that we may complete the reconnaissance of the solar system, followup on the most significant discoveries of the past decade, and continue a flow of data about our world's solar system environment. NASA efforts now underway will yield specific mission options for consideration by Congress next year.

In the meantime, it is necessary to stop the dismantling of the base programs in planetary science by restoring $40 million in proposed cuts in the fiscal year 1983 budgets. Even with these cuts restored, the program will be lean and unable to fully capitalize on the wealth of new planetary data returned during the past decade. But the scientific and technical capability will be preserved, and a rich harvest of understanding will be achieved.

APPENDIX: IMPACT OF ADMINISTRATION'S FISCAL YEAR 1983 BUDGET PROPOSAL FOR PLANETARY RESEARCH AND REQUIRED RESTORATIONS

The attached table lists the fiscal year 1981 budget line items for the Mission Operations and Research and Analysis parts of the NASA planetary program. Also shown are the budget levels proposed for fiscal year 1983 by the Administration. The final column represents the restorations we believe are required to stabilize the base programs at a minimally adequate level. We take fiscal year 1981 as the base year because many of the cuts proposed by the Administration last autumn were subsequently implemented in the present fiscal year 1982 budget, which we believe is inadequate.

MISSION OPERATIONS: $15 MILLION RESTORATION

Voyager extended mission

NASA had intended to being Jupiter and Saturn Data Analysis Programs to support continuing analysis by the Voyager science teams and to open the vast wealth of new Voyager data to the wider community of planetary scientists. $4 million was to be budgeted for Jupiter, another $4 million for Saturn. About half the money would have supported the Voyager teams, with the rest supporting the broader scientific community. But the fiscal year 1983 proposal provides only 75 percent of intended support for the Voyager teams and just 25 percent to other scientists. A $4 million restoration is required.

Pioneer Venus Orbiter operations

An extensive program of unique measurements by this spacecraft, now in orbit around Venus, has been planned to last until 1992, when the spacecraft will enter the Venusian atmosphere. It can measure the interaction of the planet with its space environment, the planet's gravity, and the cloud motions in ways not possible earlier in the mission. Special measurements during reentry are planned for 1992. The zero-dollar budget means the spacecraft must be turned off permanently by January 1, 1983 (it could never again be reacquired), unless $6 million is restored.

Pioneer 6—11 extended missions

These spacecraft continue to send back important data about the solar system and interplanetary space. Pioneers 10 and 11 are traveling in opposite directions into the farthest reaches of the solar system. It is hoped that they will penetrate the "heliopause" and make the first direct measurements of the interstellar medium. For lack of just $2 million in the proposed budget, they would be turned off permanently on January 1, 1983.

Planetary Flight Support

Engineering efforts designed to assist ongoing mission activities (including upgrading computers and designing information systems for Galileo) would be cut back. About $3 million would partially restore this effort.

RESEARCH AND ANALYSIS: $25 MILLION RESTORATION

Halley's Comet watch and Giotto experimenters

America is not sending a mission to Halley's Comet. But there is a program of ground-based observation plus a few American scientists participating on the European Giotto mission. Proposed cutbacks would incapacitate the Halley Watch Program and provide the Giotto experiments with less than minimally adequate funds. A restoration of $0.7 million is needed.

Basic research programs (planetary geology, planetary materials, geochemistry/geophysics, planetary astronomy, planetary atmosphere)

After slow erosion over several years and a 20-percent real cutback in 1982, these programs would suffer sharp further cuts in fiscal year 1983. Despite attempts by NASA officials to preserve the people in the scientific community, about 170 principal investigators would lose their funding. This would mean the loss from planetary science of many hundreds of first-rate scientists, research assistants, and students. Technical staffs would disband. The operations of many laboratories and observatories would be curtailed or closed down, including the Infrared Telescope Facility in Hawaii.

The opportunity to understand a whole decade's worth of remarkable planetary data would be undermined. All five of these major scientific sub-disciplines of planetary science address fundamental issues as to how planets formed and evolved, how atmospheres and weather works, about how geological processes affect planetary surfaces such as the one on which we live. Such fundamental new understanding would be real pay-off from the large investment American taxpayers made in the Mariner, Viking, Pioneer, and Voyager missions and in the state-of-the-art observatories and laboratories developed with NASA support. Much of the realization of that investment would be lost by decimating the research enterprise by further cutting back on these basic programs.

The restoration of $15.5 million, divided among the five programs as shown in the table, would enable this research effort to proceed at the 1981 level.

Advanced programs

The future of the American planetary program depends on sophisticated scientific and engineering studies of future economical mission opportunities and spacecraft design. This effort needs a restoration of $5.1 million.

Mars data analysis program

Despite the wealth of quite recent Viking data that has barely been looked at, this productive research effort would be totally shutoff. It was supposed to be $3 million during the current year. After the stunning success of the Viking missions, America's sudden disinterest in Mars would become complete. Further research on Mars would be possible only at a minimal level, and only within the context of the basic research programs, which (as described above) are being sharply cut back themselves. A restoration of $2.4 million would support this program at the level originally intended for fiscal year 1983, which was already down from the Fiscal year 1981 level.

Instrument definition

It has long been recognized that a modest investment in new state-of-the-art instrumentation development could have rich rewards if applied in future missions. A restoration of $1.3 million would give this forward-looking effort some renewed vitality.

Mid-level facility (IR telescope)

This particular item in the fiscal year 1982 budget is a one-time-only item that needs no additional funds in fiscal year 1983. The Infrared Telescope Facility itself should be supported under the basis research program in planetary astronomy, discussed above.

RESTORATION OF FUNDS REQUIRED FOR A VIABLE PLANETARY PROGRAM

Line item	Fiscal Year 1981	President's proposed fiscal year 1983	Required restoration for fiscal year 1983
Mission operations and data analysis	$61.8	$26.5	+$15.0
Galileo operations	0	0	....
Voyager operations	25.7	0	....
Voyager extended mission	3.3	14.0	+4.0
Pioneer/Venus extended operations	4.7	0	+6.0
Pioneer 6–11 extended mission	2.0	0	+2.0
Helios extended mission	.1	0	....
Planetary flight support	26.0	12.5	+3.0
Research and analysis	50.7	35.5	+25.0
Halleys Comet watch/experiment	0	1.5	+.7
Geology	4.8	4.0	+1.8
Planetary materials	9.6	6.1	+5.5
Geochemistry	7.7	6.5	+2.8
Astronomy	7.0	5.5	+3.0
Atmospheres	5.4	4.1	+2.4
Advanced programs	8.8	5.5	+5.1
Mars data analysis	4.4	0	+2.4
Instrument definition	3.0	2.3	+1.3
Midlevel facility (IR telescope)	0	0	....

STATEMENT OF JOHN E. STEINER, VICE PRESIDENT CORPORATE PRODUCT DEVELOPMENT, THE BOEING CO.

A great deal has been said about foreign competition and erosion of U.S. market share in aeronautics. Large jet transports make up by far the largest dollar value of the erosion, and the bottom line to our economy lies in the questioned security of thousands of jobs in the years ahead. This erosion has been precipitated by the successes of the French-dominated Airbus Industrie. My purpose in submitting a statement is to quantify the strength and commitment of the French Government to a broad front total technology effort. Such enlargement and clarification may affect judgments as to how rapidly our industry erosion may extend and whether it is likely that trade negotiations such as those indicated by Mr. Piper will serve in the achievement of a "level playing field." These comments are also submitted because recent French expansion in research commitments have gone largely unreported by the U.S. press and are therefore largely unknown by the U.S. political structure and the nation's business community.

The following comments are based on discussions in many areas including the National Academy of Sciences, M.I.T., and aerospace companies, but do not represent specific statements by these agencies.

The Government of France has for over a decade followed industrial policies stimulating its high technology industries. This government financial stimulation extends from technical education and research infrastructures to industrial risk taking and the export subsidies for French high technology products. Prime Minister Mitterand is apparently accelerating this effort. He is personally leading it and is marshalling the French citizenry to its endorsement. The French Minister of Research and Technology has been elevated to be one of the five senior minister of government with specific research expansion responsibilities. Research outlays are to double within three years. Government and industrial researchers are to increase four percent a year for the next decade. Government support centers on aerospace, electronics and others such as biotechnology, and aims at the world market, particularly the less developed countries with high expansion potentials. In some cases, such as aircraft, France is serving as a leader of programs financed by other European national treasuries such as West Germany as well as France, and is resorting to significant export subsidies of several types. France, in many cases, is developing its own technology, not just using ours. This massive infusion of government financial aid and emphasis at a time when the U.S. is following an opposite course, can be expected to gain for France and its associates substantial portions of world markets formerly served by the U.S., with a consequent erosion of American jobs and tax base.

STATEMENT OF CLIFTON F. VON KANN, PRESIDENT, NATIONAL AERONAUTIC ASSOCIATION

Mr. Chairman and members of the subcommittee, on behalf of the more than 250,000 members of the National Aeronautic Association (NAA), its chapters, divisions and affiliates, I appreciate the opportunity to comment on the NASA FY-1983 aeronautical R&D authorization.

BACKGROUND

A few words of background may be helpful. NAA is the oldest national aviation organization in the United States. It was founded as the Aero Club of America in 1905 less than two years after the Wright Brothers' first flight at Kitty Hawk. Both the Wrights were among our early members, as were nearly all the great figures who helped mark U.S. aviation history from Kitty Hawk in 1903 to the landing on the moon less that 66 years later.

Throughout its 77 years NAA has avoided special interest objectives and has instead maintained one prime purpose, to keep the United States first in air and space flight. With this goal, our members have played important roles in the forward thrust of U.S. aviation over the years. At the time of the moon landing in 1969, the preeminence of U.S. in all elements of air and space flight was nothing less than awesome and a major element of U.S. national power and prestige.

Sad to say, this picture has changed. During the Carter Administration, mounting concern was expressed about the state of aeronautics in the United States. One of the most lucid expressions of this concern was made during the 1980 election campaign by then-Governor Ronald Reagan who said in a letter to me:

"Recognizing, as I do, the importance of aviation to our Nation's economic and military strength, I am deeply concerned about the state of aeronautical research and development, the aerospace and air transport industries, and the airport/airway system in the United States.

"The technical preeminence of our country in aircraft and missile design and production, along with an unparalled record for the safe and efficient air transportation, has made us the leader of the world in aviation and has greatly contributed to the national defense. The technical excellence of our manufacturers, backed by airline orders that trigger production runs, has resulted in United States commercial transports capturing 90 percent of the world's airline market. Aviation has also been a vital factor in our international negotiations.

"Under the Carter Administration this source of national power is being eroded. The U.S. aerospace industry is now faced with aggressive competition from abroad, and our exports are slowed by foreign trade barriers. In 1979, U.S. commercial transports accounted for only 70 percent of world sales. With general aviation and rotorcraft the trends are more alarming, and the U.S. is virtually a non-competitor in the growing market for commuter aircraft. Thousands of aerospace jobs are at stake."

In the light of these excellent and well expressed views, it is disconcerting to consider the aeronautical scene 18 months later and to find that NASA aeronautical R&D is not faring as well as social entitlement programs.

It is more than disconcerting—alarming, in fact—to realize that the unique cooperative arrangement between NASA, industry and academia—a remarkable national resource which has resulted in the world's finest civil and military aircraft—is being cut back and partially dismantled without any reasonable or logical formula for an alternative solution.

As a matter of fact, the OMB position that system technology development for civil aviation must be shifted to industry has been shot down in flames before this very Committee and before the counterpart committee in the other body. Expert testimony on this subject has demonstrated conclusively that this burden cannot be added to the already high risk inherent in conventional airplane production programs without creating a risk that no prudent executive can, in good conscience, accept.

Yet OMB is proceeding down this road without one iota of proof that the new concept—industry financing of civil aviation system technology development—can work or be made to work.

This points to the fundamental policy issue underlying NASA's fiscal year 1983 budget.

OMB is establishing national policy on vital issues by the way it funds—or fails to fund—programs. Such a procedure is putting the cart before the horse. It is not the way to establish national policy. Policy decisions should be made first, and budget programs should follow.

Specifically, we should set our goals by examining the situation in which our Country finds itself in today's world and deciding what courses of action we must pursue to insure national survival, continued economic growth and adequate employment levels.

What do we see as we examine the world around us?

The Soviet Union, a proven failure in its political and economic theory, continues to build its military machine and to use this machine to enhance its world position.

Through third party subversion, the USSR seeks to control the material wealth of Central Africa and turn the Resources War against us.

The USSR continues to improve its occupation of space with a slow but steady and well thought out space program.

Meanwhile, our allies are stepping up their competitive efforts in the civil aircraft market and plan to dominate this market by 1990.

How are we reacting to these challenges?

We are rearming; this is good.

We are seeking to rebuild our damaged economy and our mobilization industrial base; this is essential.

We are presumably fighting the Resources War on a political level; this is appropriate, although the effectiveness of our response is difficult to evaluate.

We are reducing—or attempting to reduce—the government investment in civil aviation R&D, even though the investment is miniscule and the returns enormous. This is stupid in the short term and possibly suicidal in the longer run.

Why is this attempted reduction stupid?

Because civil aeronautics is the one area of high technology where the United States still holds an unquestioned lead. Our domination of the world aircraft market depends on maintenance of this lead; without it, our great aerospace companies will suffer diminished capacity to undertake both civil and military programs.

Because no country has mounted effective civil aircraft programs without significant government support.

Because the potential for future advances in aeronautical R&D is enormous.

Because without government support of civil aviation system technology development, the cost of military aerospace products will be higher.

How, then, did our Country, the technological leader of the world, fall into this illogical situation?

One reason is that there have been misconceptions about aeronautical R&D. Because military and civil end products have less commonality than in years past, it has been assumed that there is less commonality in research. This is wrong. There is a commonality of more than 90 percent between basic R&D for the military and civil sectors.

The other misconception is that there is a clean break between basic research and system technology development. This is also wrong. The process is a continuing one which moves technology generated by basic research into the early phases of system technology development. The extent of these development programs varies according to circumstance. Sometimes they require technical demonstration—in rare cases, technical validation.

Thus the virtual elimination of systems research and technical demonstration programs from the fiscal year 1983 budget was a grievous mistake which should be set right before greater and more serious damage is inflicted on the U.S. technology base.

Specifically, NAA recommends that:

The energy efficient aircraft research program be restored and carried through to completion. This would involve about $20 million in fiscal year 1983 funds for integrated controls ($1.1 million), composite aircraft structures ($2.0 million), advanced turboprop research ($9.8 million) and completion of the energy efficient engine which is already 99 percent complete ($7.0).

The Terminal Configured Vehicle program at Langley be funded for $7.6 million in fiscal year 1983.

Turbine engine hot section research be continued in fiscal year 1983 with funding of $4.7 million.

Advanced rotorcraft research be continued in fiscal year 1983 with funding of $4.5 million.

Broad property fuel research be continued in fiscal year 1983 with funding of $4.2 million

Low speed system technology, including QSRA work, continue in fiscal year 1983 with funding of $3.8 million.

Fundamental research in the R&T base be restored with funding of $16 million in fiscal year 1983.

System studies for development of commuter aircraft technology be pursued in fiscal year 1983 with funding of $3 million. (It is extremely important that something be done to improve U.S. capabilities to produce competitive commuter aircraft.)

These recommendations, if implemented, would bring the aeronautical R&D budget near the $300 million level and start to reverse the recent unfortunate trend toward U.S. technological disarmament.

It is an old military principle that a commander's resources should be used to exploit successes and not dissipated to shore up failures. Aeronautical R&D has been one of our Country's greatest success stories. We urge that the success be exploited, not rejected.

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., March 24, 1982.

Hon. HARRISON H. SCHMITT,
U.S. Senate, Committee on Commerce, Science, and Transportation,
Washington, D.C.

DEAR SENATOR SCHMITT: I am responding to your letter of February 19, which was addressed to the Foundation's Director. You indicated that the Subcommittee on Science, Technology and Space was conducting a review of the space activities of, and NASA programmatic relationships with, other agencies of the government. You also asked for a presentation of fiscal year 1983 space related programs in some detail.

As you are aware, the Foundation's budget request for fiscal year 1983 is currently under review in Congress. The handling of proposals and the making of awards for support of research is a continuous process, normally requiring six to nine months per proposal following receipt by the Foundation. Many of the proposals now under review in the NSF seek support beginning in fiscal year 1983, and many more will be received in the coming months. We cannot predict which of these individual proposals will be funded and because all of them are unsolicited, we cannot predict how many that we may receive will be space related. We are now, however, supporting a number of projects that were funded in prior fiscal years and that will continue into fiscal year 1983. From among these we have selected those that receive data or other support from NASA, those that contribute in some readily identifiable fashion to NASA's programs, those that are joint or cooperative efforts, and those that are in some other fashion related to NASA space activities. The funding involved in these projects is as follows:

	In thousands
Astronomical sciences (AST)	$700
Atmospheric sciences (ATM)	1,400
Earth sciences (EAR)	400
Ocean sciences (OCE)	2,600
Polar sciences (DPP)	1,500
Total	6,600

The $700,000 shown for the Astronomy (AST) Division is an estimate of the cost to NSF grantees and contractors for use of the NASA Infrared Telescope Facility, for work split funded or partially funded by NSF and NASA, and for use or analysis of data from other NASA facilities. Over 70 Principal Investigators are involved in the $700,000 of space related work; they receive a total of about $7.OM from the Foundation. There are NSF Forms 4 enclosed describing work presently in progress which is similar to the kinds of effort that we anticipate supporting in fiscal year 1983. For the remaining Divisions there is an NSF Form 4 enclosed describing each individual project from which the dollar values above were derived. Each form is anotated with the approximate amount of funding devoted to the work described that will be spent during fiscal year 1983.

For fiscal year 1983, the Foundation has requested $63.2M for support of the National Astronomical Centers and for project support in astronomy, $6.OM for solar-terrestrial research, and $7.0M for research in aeronomy. These programs support individual research projects and also provide for the operation and maintenance of major ground-based facilities used in the conduct of those projects. Much of this work in a broad sense is space related. If the Subcommittee wishes to have additional information on these efforts, we will be happy to provide it upon request.

I hope that the foregoing information is responsive to the Subcommittee's needs. If there is anything further we can do to assist in the review, please let me know.

Sincerely yours,

FRANCIS S. JOHNSON, *Assistant Director.*

COUNCIL OF ENGINEERS AND SCIENTISTS ORGANIZATIONS,
April 23, 1982.

Hon. HARRISON H. SCHMITT,
U.S. Senate, Committee on Commerce, Science, and Transportation, Washington, D.C.

DEAR SENATOR SCHMITT: I would like to offer the following comments in response to your letter of April 12, 1982.

The National Aeronautics and Space Administration (NASA) has among its objectives mandated by the National Aeronautics and Space Act of 1958 the following:

"The preservation of the role of the United States as a leader in aeronautical science and technology." and, "The most effective utilization of the scientific and engineering resources of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment."

NASA (and its predecessor, the National Advisory Committee for Aeronautics—NACA) has been the focal point for our nation's aeronautical research for more than 60 years. Their innumerable contributions to scientific and technical knowledge have been a vital element in establishing and maintaining the United States' preeminence in both civil and military aeronautics. Beginning with the NACA and continuing to the present, NASA has played a vital role in the development and transfer of new and advanced technology to industry, and this, too, has been an invaluable contribution to the Nation's superiority in aviation. As Senator Nancy Kassebaum has stated:

"Our leadership in aviation is . . . directly attributable to the successful efforts of the NACA/NASA research centers working in coordination with our universities and private industrial labs. The public benefit in terms of employment, national defense, export trade, and air safety are enormous. . . . They more than justify the expenditure of public funds that have been associated with aeronautic research and development."

The objectives of NASA and the continuing stream of benefits derived therefrom would be put at substantial risk by budget reductions being proposed. Such reductions will erode NASA's ability to advance basic research and non-product oriented systems technology. It will also seriously deminish the cadre of trained aeronautical research specialists and the operation of research facilities. Our aviation industry's world-wide leadership and the concomitant economic returns to our economy in employment, balance of trade, and tax revenues would be jeopardized.

To expect the private sector to take up the slack is unrealistic, especially in the field of basic aeronautical research and technology. Such an approach would predictably result in an overall diminution of capability, through wasteful duplication of facilities, overlap in programs, and the loss of much non-program focused research.

Technology readiness is a long-term effort. It demands a continuity of non-product oriented research that extends beyond the capability of industry. We can ill afford the damage to our technology base which will ensue if NASA's aeronautics budget continues to be reduced. The benefits derived in the form of jobs, balance of trade, and national security make the preservation of a viable NASA aeronautics program a justifiable investment.

NASA should, in our view, remain the central body of technical expertise and continue to be the focal point for data related to aeronautics technology and assure their domestic availability. NASA should be engaged in research and the development of advanced technology and the demonstration and validation of such technology. NASA should continue to have an important role in the fostering of new ideas within the aeronautics community.

The NASA aeronautics program is an essential element of the continued health of the civil aircraft manufacturing industry. Continued reductions in NASA aeronautics programs will contribute to the further increase of the already ominous penetration of the marketplace by foreign competition. American industry has already lost approximately 25 percent of its commercial transport market to the European aircraft industry. The commuter aircraft industry is yet another example—although commuter service is a growth industry in the United States, most of the new equipment is being developed by foreign manufacturers.

The next generation of what must surely be more efficient aircraft may well be supplied by foreign competitors if the loss of momentum in this Nation's aeronautical technology is permitted to continue. There are on the horizon new technological advances that offer the potential for dramatic improvement in aircraft efficiency. These include, among others, Prop-fan Propulsion System, Large Composite Primary Structures, and Laminar Flow Control Technology. Such programs should be accelerated to permit the continuation of our Nation's technological leadership in aeronautics.

In the past the small, but continuous investment in the NASA aeronautics program has played a major role in maintaining our Nation's technological superiority. That technology, however, is the product of the American men and women who constitute the engineering, scientific, and technical community. It is their talent and dedication encouraged and supported by the partnership of government, industry and the universities that have produced that technology.

Currently the three largest American manufacturers of commercial air transports are laying off engineers, scientists, and technical employees. Concurrently, there continues to be a great public gnashing of teeth and wringing of hands over the fact that several other countries are now producing more engineers and scientists per capita than the United States. Is this the time for our government to tell the American technical community, and those young, talented people who are now considering becoming a part of that community, that the government no longer will provide support and encouragement for the advancement of aeronautics research and technology? We think not. We urge continued support for the NASA aeronautics research and technology program.

Cordially,

LEONARD C. RICKS, *Chairman.*

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